THE EFFECT OF CHLOROFLUOROCARBONS ON THE OZONE LAYER

HEARING

BEFORE THE

SUBCOMMITTEE ON TOXIC SUBSTANCES AND ENVIRONMENTAL OVERSIGHT

OF THE

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THURSDAY, JULY 23, 1981

U.S. SENATE, COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS, SUBCOMMITTEE ON TOXIC SUBSTANCES AND ENVIRONMENTAL OVERSIGHT,
Washington, D.C.

The subcommittee met at 2 p.m., in room 4200, Dirksen Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Present: Senators Gorton, Bentsen, and Baucus.

OPENING STATEMENT OF HON. SLADE GORTON, U.S. SENATOR FROM THE STATE OF WASHINGTON

Senator GORTON. I wish to call this meeting to order. This hearing of the Subcommittee on Toxic Substances and Environmental Oversight will now begin.

During the course of this hearing we will attempt to discover the current status of scientific inquiry and knowledge about the effect of chlorofluorocarbons on the stratospheric ozone layer and the effect of increased doses of ultraviolet radiation on the human body. This information is important because the Senate will soon be faced with the question of how much regulation is appropriate in this field.

The Senate will be presented with several alternatives with respect to the regulation of chlorofluorocarbons. We can decide to authorize regulation based on a fear of significant harm to the health of Americans. We can decide to wait until there is clear and unequivocal proof of both the validity and effects of the stratospheric ozone theory until we do any regulating. Or we can set a date certain when we will take all of the scientific information available and make a final determination of how much to regulate the manufacture of and use of CFC's.

I do not think that we need to answer that question today. It is important, nevertheless, to state this is the political question which we are faced with and that is the background of today's hearing.

I have to state in advance that as almost all of the witnesses here know, the Senate is very, very busy today. We are in the midst of a 2-week debate on the President's proposals for tax cuts. We have special permission to hold this meeting from the Senate, the normal rules of which do not permit committees to meet more than 2 hours after the beginning of a daily session of the Senate. There is, however, very likely to be a series of rollcall votes during the course of this hearing, and when they take place, when we are notified by the buzzers and the lights behind all of you out there, the committee will have to recess for a few minutes in order for the Members to go and vote and to return.

In addition to that, I may say that at 5 this afternoon, approximately, there will be a brief floor debate on something close to the chairman's heart, the Seattle Public Health Service Hospital. The chairman will be required to be on the floor at that point.

Understanding that, we hope that you will both indulge our absences here on the panel of Senators and that you will try, where possible, to summarize your written testimony. That will help us in two ways: First, to see to it that everyone is heard and, second, to give us more opportunity to ask you questions.

I can assure every witness that his or her written testimony will be included in the record in full.

With that, we would ask that the first panel come and sit at the witness table: Dr. Molina, Dr. Bloomfield, Dr. Greenwood, Dr. Anderson, Dr. Clark, and I think Dr. Tilford and Dr. Wiser as well.

Senator Baucus, the ranking minority member of the subcommittee, is here. Senator, do you have an opening statement?

Senator **BAUCUS**. No statement. Thank you.

Senator **GORTON**. Dr. Molina, that was a hairbreadth arrival. You are our lead-off witness. You may proceed.

STATEMENTS OF MARIO MOLINA, ASSOCIATE PROFESSOR OF CHEMISTRY, DEPARTMENT OF CHEMISTRY, UNIVERSITY OF CALIFORNIA, IRVINE, CALIF.; PETER BLOOMFIELD, CHAIRMAN, DEPARTMENT OF STATISTICS, FINE HALL, PRINCETON UNIVERSITY, PRINCETON, N.J.; LAWRENCE GREENWOOD, DIRECTOR, ENVIRONMENTAL OBSERVATION DIVISION, OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C., ACCOMPANIED BY SHELBY TILFORD; JAMES G. ANDERSON, PROFESSOR OF CHEMISTRY, PRINCIPAL INVESTIGATOR, ATMOSPHERIC RESEARCH PROJECT, HARVARD UNIVERSITY, CAMBRIDGE, MASS.; AND EDWIN H. CLARK, ACTING ASSISTANT ADMINISTRATOR, PESTICIDES AND TOXIC SUBSTANCES, ENVIRONMENTAL PROTECTION AGENCY, WASHINGTON, D.C., ACCOMPANIED BY HERBERT WISER

Dr. **MOLINA**. Mr. Chairman, members of the subcommittee, my name is Mario Molina of the University of California at Irvine. I appreciate the opportunity to appear here today, I apologize for being a little late.

In 1974, Professor Rowland and I published an article outlining the theory which links the release of industrial chlorofluoromethanes, so-called CFM's, with the depletion of the ozone layer of the stratosphere. I should like to first review this theory briefly and then I will try to summarize the scientific findings of recent years which have some bearing on the validity of the theory.

Nearly one million metric tons of the chlorofluoromethane gases, which are of industrial origin, are being released every year to the atmosphere. These compounds are chemically very inert and are practically insoluble in water. Hence, they are not destroyed in the lower atmosphere but slowly diffuse into the upper atmosphere.

At about 10 to 12 miles above the Earth's surface they are decomposed by ultraviolet radiation from the Sun, releasing chlorine atoms. The free chlorine atoms react chemically with ozone, a compound which is naturally present at those altitudes. The nature of this chemical reaction is such that one atom of chlorine is capable of destroying a large number of ozone molecules through a so-called catalytic chain mechanism.

Ozone is a form of molecular oxygen, sort of a peculiar form of oxygen which we breathe. This ozone exists in small quantities in the stratosphere, which is the region between about 8 and 30 miles above the Earth's surface.

The ozone layer in the stratosphere shields the surface of the Earth from high-energy ultraviolet radiation emitted by the Sun. The presence of ozone at high altitudes is also responsible for the temperature increase which gives rise to the existence of the stratosphere.

Ozone is continuously being formed by the action of sunlight on oxygen and being destroyed by various chemical processes. The introduction of chlorine atoms increases the rate of destruction of ozone without affecting its rate of formation, the net effect being a depletion of stratospheric ozone.

The theory predicts that in the process of consuming ozone chlorine atoms and chlorine monoxide molecules should be rapidly interconverted to each other. Chlorine-containing species are expected to participate in many other chemical and photochemical reactions in the stratosphere.

Compounds such as methane, nitrogen oxides, and the so-called HOX radicals, are natural constituents of the atmosphere, present in trace amounts. The C1 catalytic chain mechanism may be interrupted, for example, by reaction of the C1 atom with CH4 to produce the relatively stable molecule HC1; or, by reaction of C10 with NO_2 or HO_2, to produce a variety of species which eventually break down through solar radiation, returning chlorine to its catalytically active form.

In order to estimate the magnitude of the ozone perturbations resulting from a given CFM release, atmospheric computer models are employed which incorporate information on atmospheric motions as well as information on the rates of over a hundred chemical and photochemical reactions. These chemical reaction rates are measured in the laboratory. Due to the complexity of atmospheric motions, the calculations have been mainly with "one-dimensional" models, an approach which attempts to average these complicated atmospheric motions and also the concentration of chemical species over latitude and longitude, leaving only their dependency on altitude and time.

Current results from one-dimensional models predict an eventual 5- to 10-percent depletion of stratospheric ozone if CFM release continues indefinitely at the present rate. If the CFM release were to be eliminated in the next decade, ozone would continue to decrease for at least another decade and would then slowly increase, taking roughly a century to reach normal values again. So these are very long times involved here.

The models also indicate a present-day ozone depletion level of about 1 percent due to past CFM release. This value cannot be confirmed in the near future by direct observation of stratospheric ozone levels due to a poorly understood long-term variability of about plus or minus 5 percent in the natural ozone levels.

Besides the two important CFM's, F-11 or F-12, other chlorofluorocarbons are currently finding technological use, although not at the high tonnage level of F-11 or F-12. Among them, F-113 and F-114 are expected to affect stratospheric ozone in much the same manner as F-11 or F-12. F-22, used mainly as a refrigerant, is about 15 times less effective than F-11, on a molecule-per-molecule basis, in terms of stratospheric perturbations because some of the F-22 is destroyed by reaction with OH radicals in the lower atmosphere. This increased reactivity is due to the replacement in the CFM molecule of a chlorine or fluorine atom by a hydrogen atom.

Similarly, methylchloroform, used in rather large quantities as an industrial solvent, is partially destroyed in the lower atmosphere, but a significant amount does reach the stratosphere, releasing chlorine atoms. Methyl chloride is also in technological use but in small quantities compared with the biological sources of methyl chloride which provide the natural chlorine background to the stratosphere.

The CFM's now contribute a larger amount of chlorine to the stratosphere than all natural chlorine sources.

Let me now address the question of the current validity of the theory in light of recent scientific findings.

A large number of scientific groups has been examining various aspects of the ozone depletion theory for the past 6 or 7 years, so that a substantial amount of information is now available.

There is little question about the fundamental aspects of the problem: A large number of measurements of CFM concentrations indicate that CFM's indeed accumulate in the lower atmosphere and that they do reach the stratosphere at the predicted altitudes. No quantitatively important removal reactions in the lower atmosphere have been identified for the CFM's, and all of the evidence is consistent with dissociation by sunlight in the stratosphere being the primary destruction process.

Chlorine atoms and chlorine oxide molecules are indeed found in the stratosphere, as has been shown mainly by these measurements, together with other species, including HCl, O, OH, HO_2, NO and NO_2. The observed concentrations are in reasonable agreement with the theory, particularly if one takes into account atmospheric variability as well as some of the limitations of the models.

For example, one-dimensional models cannot be expected to represent latitudinal variations since they average them out.

The total amount of chlorine, regardless of chemical form, has also been measured recently in the stratosphere, and here again the result is in reasonable agreement with theory, indicating the absence of an as yet undiscovered compound which might tie up a significant fraction of the chlorine and hence invalidate the theory.

The possible consequences of ozone depletion have also been intensively studied for the past several years. The effects discussed, for example, in the reports of the National Academy of Sciences include human skin cancer, damage due to increased ultraviolet radiation on other biological and ecological systems, and climatic effects. I would like to refer briefly to some of these potential climatic effects, which in my opinion have not received as much attention as they should.

As I mentioned earlier, the theory predicts a 5- to 10-percent depletion of total atmospheric ozone for continued release of CFM's at 1975 rates. The theory also predicts a large local ozone depletion in the upper stratosphere; namely, about 40 percent to 50 percent at altitudes around 25 miles, assuming the same continued release of CFM's at 1975, or current, production levels. That is, the prediction is about half of the ozone will disappear at those altitudes. If the production levels increase, the depletion will be correspondingly higher.

It turns out that much of the uncertainty in the prediction of total ozone loss is due to the complicated nature of the chemistry in the lower stratosphere. In contrast, the calculations involving the large upper stratospheric perturbations are more straightforward and have undergone no significant revisions in the past 5 or 6 years.

More importantly, a rather strong body of observational evidence has evolved during this time. The key chemical species at those altitudes, which include chlorine atoms, chlorine monoxide, oxygen atoms and ozone itself, have all been measured. Furthermore, there are now indications from satellite data that indeed the natural ozone profile has already been perturbed and that at present the ozone in the upper stratosphere shows measurable depletion.

Why should we worry about this upper stratospheric ozone depletion? We are concerned here about a rather nontrivial perturbation to an important global process, a perturbation that on a geological time scale is occurring extremely rapidly. It is the ozone which is responsible for the peculiar temperature increase of the atmosphere at about 8 miles above the Earth's surface. The very existence of the stratosphere results from this temperature inversion. Thus, the temperature—and hence, the climate—of the stratosphere might have already changed and will continue to do so for the next 50 to 100 years through interactions with the CFM's which have already been released to the atmosphere.

Unfortunately, it is not yet possible to predict with any assurance whether general climatic changes here on the surface of the Earth will result from such stratospheric perturbations. On the one hand, the stratospheric climate is not strongly coupled to the climate at the surface. On the other hand, a global change in surface temperatures as a result of the CFC's is in fact likely, and the resulting economic and social effects could be quite substantial, particularly if one considers that associated with such apparently small global temperature changes there could very well be, for example, large local changes in rainfall.

In summary, if the worldwide population of CFM's continues to increase, local ozone would be depleted by a much larger factor. These levels are clearly unacceptable, in my view. It seems their potential impact on the biological scene would be quite serious.

Again, many thanks for the opportunity to speak with you today.

Senator GORTON. Thank you, Doctor.

I think we will complete the testimony of the panel before we begin questions.

Our second witness will be Dr. Peter Bloomfield.

STATEMENT OF PETER BLOOMFIELD

Dr. **Bloomfield**. Mr. Chairman, members of the subcommittee, I am very grateful for this opportunity to give some details, however brief, of some of the analyses that have been made of observed ozone levels.

My name is Peter Bloomfield. I am in the Department of Statistics at Princeton University. I have been involved with analyses of observed ozone data now for a couple of years, although my interest in the question of the stratosphere goes back more years.

In my testimony this afternoon I shall try to answer the question: "Can we tell whether the hypothesized depletion of the ozone column is in fact taking place?"

It is also important to know what depletion we shall be able to detect in the future, say in the years 1990 or 2000. The answers can be found step by step.

First of all, what data are available?

There are several types of measurements that can be used to try to answer the question of whether or not the ozone layer has been depleted in the way that the model-based calculations indicate. The bulk of these measurements may be classified in two ways: They may be made from the ground or from a satellite; they may be measurements of the total ozone column, or of the density of ozone at various heights—the ozone profile.

Different instruments are used for each type of measurement. The longest-running and most reliable ground-based total column data are collected using the Dobson spectrophotometer, which has been in use for over 50 years. This is also used to make profile measurements, using the Umkehr technique.

There are now some 75 stations making Dobson measurements, but only around 35 have long and reasonably complete records. These are exclusively located on land masses, and a large majority are in the Northern Hemisphere. They thus provide less than complete coverage of the globe.

Satellite data have been collected for a little over 10 years using a variety of instruments on several satellites. Satellite data provide excellent coverage of the globe and have answered many questions about the way that ozone varies from place to place.

However, the short records and calibration problems have prevented them so far from being useful in measuring trends. For these reasons, most studies of possible trends have depended on ground-based measurements—Dobson total column and Umkehr profile data.

Next, what do the total column data show?

First, I should point out that it is not easy to detect trends as small as the hypothesized depletions. The ozone readings from a Dobson station show large annual variations, the levels in late winter being as much as 50-percent higher than in late summer. There are also large differences among stations, with levels at temperate latitudes up to 50-percent higher than those in the tropics.

These large variations tend to mask the effect of small trends, such as 1 percent or 2 percent in a decade. However, the seasonal variations can be removed, using seasonal adjustment techniques—similar to procedures used by the Bureau of the Census. The adjusted data still fluctuate quite enough to mask small trends. When the adjusted data are averaged across a number of stations, however, some of the fluctuations tend to cancel out and relatively small global trends become detectable.

Overall, levels have increased by around 2 percent during the 22-year record, which runs from 1958 to the end of 1979, which is a period in which we have relatively good information. That 2-percent increase is not consistent with any existing model calculations. However, the 2-percent change occurred essentially before 1970, and there is essentially no trend since 1970.

Third, are the total column data consistent with an hypothesized depletion of less than 1 percent by 1980?

The short answer is yes, barely. Had ozone levels not risen steadily through the 1960's, or if there was a satisfactory physical explanation of this rise, the answer would be unqualified: Yes, the data are consistent with a depletion of less than 1 percent by 1980.

Given the rise in the 1960's, the data are, in fact, more consistent with the hypothesis that there has been no depletion. We have as yet too little data to decide between these hypotheses.

Fourth, how large would a depletion have to be before we could expect to detect it?

The present consensus is that we would have detected a depletion of 2.5 percent by 1980—some several times larger than the currently predicted depletion. This figure is a compromise between statistical analyses of Dobson data that suggest smaller thresholds of perhaps 1.2 percent to 2 percent, and the caution of meteorologists who feel that the Dobson network does not reveal all the sources of uncertainty. By the year 2000, the threshold for detection should be a little smaller, perhaps 2 percent, just because of the longer record. Better understanding of the causes of long-term fluctuations in ozone levels could lead to larger improvements in detectability.

Finally, would the hypothesized depletion be more easily detected in ozone profile data?

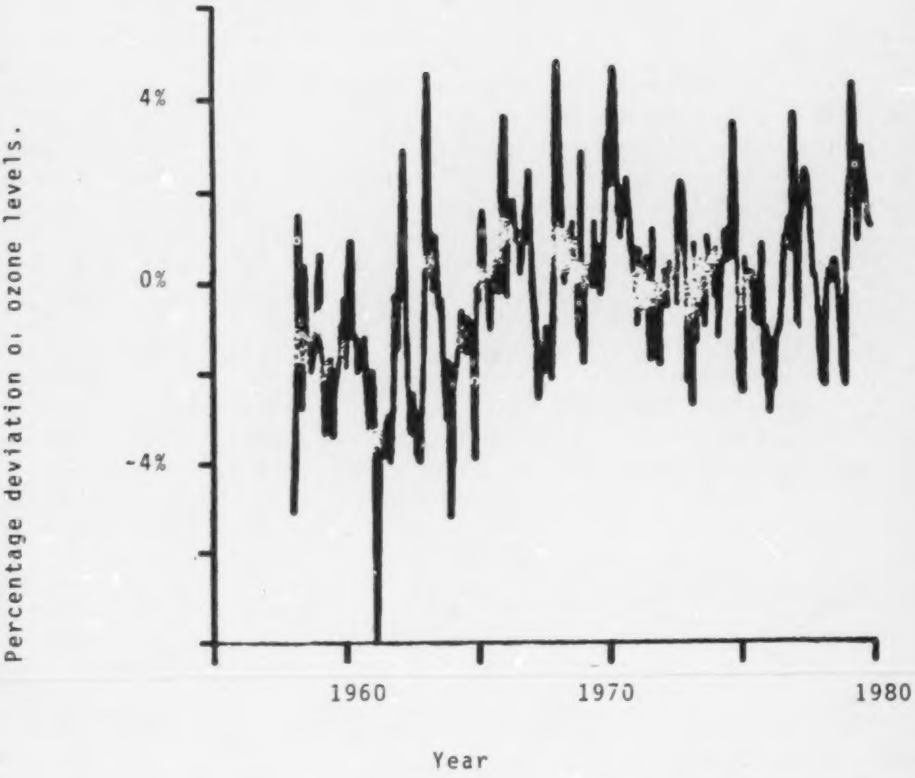
The hypothesized depletion is larger at 40 kilometers than for the total column by a factor of around 3. However, Umkehr measurements of this profile are less complete and more variable than measurements of the total column. For example, there are only 12 stations, all in the Northern Hemisphere, with appreciable amounts of data. A statistical analysis of these data measured a 4.8-percent increase through the 1970's, with a margin of error of plus or minus 6 percent. Thus a large depletion in the Northern Hemisphere at 40 kilometers is inconsistent with these data.

To summarize, a small depletion in the total column or at 40 kilometers is consistent with measurements to date. We would expect to detect depletions of 2½ percent in the total column or of 6 percent at 40 kilometers. Thank you.

Senator GORTON. Thank you, Dr. Bloomfield.

[An attachment to Dr. Bloomfield's statement follows:]

Average of seasonally adjusted data from
36 Dobson stations.



Senator GORTON. Dr. Greenwood?

STATEMENT OF LAWRENCE GREENWOOD

Dr. GREENWOOD. Mr. Chairman, I am Ronald Greenwood, Director of the Environmental Observation Division for the National Aeronautics and Space Administration. I am pleased to be here today to review NASA's Upper Atmospheric Research program and to report on our continuing efforts to understand the physics and chemistry of the upper atmosphere and to assess the impact of anthropogenic chemicals on the stratosphere.

I am accompanied today by Dr. Shelby G. Tilford, chief of our Atmospheric Processes Branch, and Dr. Robert T. Watson, program scientist of our Upper Atmospheric Research program.

With your permission, I would like to submit my written testimony for the record and summarize it verbally.

Senator GORTON. You may.

Dr. GREENWOOD. Several years ago, at the direction of Congress, NASA undertook a program designed to study the physics and chemistry of the upper atmosphere and on a periodic basis provide an assessment of the impact of anthropogenic chemicals to the Environmental Protection Agency and to the Congress. To date, two such assessments have been completed and forwarded to the Congress, the latest being January of 1980.

Today I would like to update the most recent of these assessments, the basis of which is a workshop that was held recently with some 115 scientists from a number of countries around the world participating.

At the present time, we estimate that the continued release of chlorofluorocarbons at their 1977 rates will result in a 5- to 10-percent reduction in total global ozone at steady state. This predicted impact is lower than our 1979 estimate of 15 to 18 percent as a result of new information on key rate coefficients involving OH and HO^2.

Could I have the first slide, please?

Shown in this photograph is a historical trend of the calculation of ozone depletion as a result of the CFC release and also as a result of a projected or some possible future scenario involving supersonic transports. There are a couple of points I would like to make while you examine this.

First, the absolute number for the expected or predicted ozone depletion has varied over the past few years as our level of understanding has increased. In addition, in the last few years we have seen an inverse relationship between the predicted ozone depletion resulting from the nitrogen chemistry and the chlorine chemistry. While the absolute number has varied, the basic theory has continued to evolve, and I think certainly in our laboratory and field studies additional information has allowed us to improve and increase our level of understanding.

We also estimate that CFC releases to date may have resulted in as much as a 1-percent reduction in the total column ozone and a reduction at 40 kilometers, the most sensitive altitude for ozone destruction by chlorine, of a few percent.

I should hasten to add, however, that these estimates are based on one-dimensional analytical models of atmosphere chemistry.

More recent two-dimensional results seem to be comparable with the one-dimensional predictions. However, there continues to be significant uncertainties in input data and a lack of total understanding of the chemistry and physics governing some key processes. As a result, some uncertainty remains in the absolute value of predicted perturbations.

Statistical analyses of historical ozone data from ground-based observations have been studied as a potential means for establishing upper limits of possible changes. Analyses of possible trends in the total ozone between 1970–79 compared with the period 1960–70 have produced interesting, but not necessarily conclusive, results.

Other atmospheric processes are occurring, and there is uncertainty in the statistical analysis induced by the limited data set—only about 20 years at a limited number of locations, with varying accuracy and precision. We do not think it is possible to verify the trend analysis models nor to firmly establish limits on the level of estimated impact based solely on analyses of the limited historical data available.

We believe that to date this data base has neither validated nor invalidated the photochemical models.

Could I have the next slide, please?

To illustrate the problem in trying to calculate and predict ozone trends, I have shown here 3 months of data collected from the Nimbus satellite using an instrument. This shows the variability in ozone from the poles to the Equator to the other pole. There is about a factor of two variations from the white color near the South Pole to the red and purple colors near the Equator.

What we can see in this is that ozone is highly variable. We can see that in the Southern Hemisphere the ozone does seem to follow the wave pattern which would be characteristic of the atmospheric transport taking place. In the Northern Hemisphere we can see the variability from which we are trying to extract long-term trends. This type of data has become available from, as I say, the Nimbus satellite.

Potential ozone decreases in the stratosphere due to CFC's continue to be of concern because of their long atmospheric lifetimes. While our periodic assessments vary in the absolute value of predicted depletion, the fundamental concept that free chlorine in the stratosphere reduces ozone has not changed. We continue to direct our research at reducing the uncertainty and increasing our confidence that the assessments are based on sound scientific and technical data.

In 1976, in response to congressional direction, NASA initiated a major research effort to improve the level of understanding of the physics and chemistry of the upper atmosphere and to improve the assessment of ozone depletion in coordination with the Federal Aviation Administration, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, and the National Science Foundation. A program was developed, working closely with the scientific community over the last several years.

Could I have the next slide, please?

Shown on this slide is the base goal and objectives that were developed and are now being implemented in this program. They actually fall into three categories.

First, there is a major activity in developing theoretical techniques for forecasting possible impact of a variety of activities on the atmosphere. The long-term goal of our theoretical studies is to have fully coupled radiation, chemistry, and dynamic phenomena correctly portrayed in three-dimensional models.

Progress is being made. Present codes, however, are seriously limited in how they treat the chemistry and radiative feedback.

A second activity in the program is to provide continued improvement in our input data for the chemistry that is taking place in these models. Today we are continuing to support activities in chemistry labs around the country to measure reaction rates and to measure reaction rates as a function of temperature and pressure.

Actual atmosphere observations, however, provide the key to the validation of our theoretical models and ultimately the improvement of our understanding of the stratosphere.

In the longer term, these field and satellite programs will overcome our greatest shortcoming, and that is we are limited by data.

The results of these observation programs that are now underway are being used for the improvement and validation of the present techniques. Taken together, the field measurements have developed a better understanding, although not a complete one, of the behavior of ozone and the other species in the stratosphere.

Satellites have played a key to gaining a better view globally of what is happening in this part of the atmosphere, and the early flights of the Nimbus satellite and others have provided us the first global look at what some of these phenomena are and how they are changing.

In terms of future activities, I should mention that in the 1982 budget, the administration has proposed the initiation of the development of instruments to be flown on a future satellite program called the upper atmosphere research satellite. We are presently completing a review of the conceptual design of these instruments and expect to select a set of these before the end of the year for development.

When the Congress first asked NASA to mount a research effort and provide an assessment of the stratospheric ozone, the very nature of ozone depletion due to manmade chemicals was controversial.

Today there is no longer uncertainty about the possibility of this impact, but considerable uncertainty remains regarding the magnitude of the impact from several possible perturbing influences. In short, we have narrowed the uncertainty somewhat and we have focused on the real limitations in our current ability to improve the estimates. Our major limitation today derives from the lack of simultaneous data about species and phenomena in the atmosphere, but the prospects for improving the situation through a vigorous research program are good. We in NASA continue a strong commitment to a vigorous research activity.

Senator GORTON. Dr. Greenwood, thank you very much. The balance of your statement will be included in the record.

Dr. GREENWOOD. Thank you.

Senator GORTON. Dr. Anderson?

STATEMENT OF JAMES G. ANDERSON

Dr. ANDERSON. My name is James Anderson. I am a professor of chemistry at Harvard University.

I will accept your suggestion and submit my written testimony. It begins with a review of the Rowland-Molina theory, described, needless to say, very clearly by one of its coauthors to my left. I would like to highlight in particular what measurements have told us about the fluorocarbon ozone problem by beginning first with point 1 on page 3.

The theory states that to a first approximation no physical or chemical process exists which removes fluorocarbon 11 or 12 from the troposphere except upward transport to the stratosphere. Is there any experimental evidence for a process which removes 11 or 12 at the Earth's surface or within the troposphere?

An extensive study of the global distribution of the most abundant halocarbons has been initiated in the past 5 years by a number of research groups listed in the document. The results of those studies were critically reviewed recently in the WMO/NASA document "Stratosphere 1981: Theory and Observation." Observed concentrations of those halocarbons at the end of 1979 are summarized in table 1.

Measurements of the rate of buildup of 11 and 12 in the troposphere taken over the past decade, are summarized in the figure in the document taken from Logen et al., 1981.

The conclusion extracted from these observations is that the average global rate of increase of fluorocarbon 11 is 11 percent per year and of 12 is 9 percent per year. When these data are combined with global release rates for the compounds—see Bauer, 1979—the tropospheric lifetimes for 11 and 12 are comparable to the lifetime one would predict for loss to the stratosphere alone.

Therefore, while the question of possible tropospheric removal processes must receive careful and continuous attention, there is currently no identified loss process of quantitative significance for fluorocarbon 11 and 12 except upward transport from the troposhere to the stratosphere.

Point 2: In order for the fluorocarbons to destroy stratospheric ozone, they must penetrate into the stratosphere and photochemically decompose, transforming the chlorine they contain into one or more chemically active forms. What is the experimental evidence for this penetration and decomposition?

As in the case of tropospheric observations, a significant body of high-quality data has been collected in the stratosphere at equatorial mid- and high-latitudes in the past 5 years. A sample of those data, taken from the recent work of Golden et al., 1980, and recently reviewed critically in the WMO/NASA document, "Stratosphere 1981: Theory and Observation," is shown in figure 2.

Based upon the observed penetration of 11 and 12 into the stratosphere at all latitudes and the observed rate of disappearance of these compounds with altitude, decomposition by solar ultraviolet radiation is the principal loss process for 11 and 12 in the stratosphere.

Point 3: All known sources of chlorine present in the stratosphere are of surface origin. What is the observational evidence relating tropospheric sources with the chlorine budget of chemically active forms in the stratosphere?

Based upon the recent WMO/NASA review of global tropospheric chlorine, in January 1981 there was a mean of 3.1 parts per billion chlorine atoms in the troposphere, and 79 percent of these were from manmade sources. A similar budget analysis for January 1978 shows an average of 2.7 parts per billion of chlorine atoms.

Recent measurements by Berg et al., 1980, conducted at 20 kilometers altitude between 16° and 67° north latitude for the period of April to October 1978, indicate a total chlorine mixing rate of 2.7 to 3.2 parts per billion of chlorine. Balloon-borne observations of the chlorine compounds which are currently believed to dominate the total chlorine budget of the upper stratosphere, shown in figure 3 on the following page, indicate a mean mixing ratio of 2.9 plus or minus 0.6 parts per billion in the vicinity of 40 kilometers at midlatitude.

Thus, there are no large differences encountered when the chlorine budget is examined from the point of view of (1) the troposphere inventory of source gases, (2) the total chlorine content of the lower stratosphere, and (3) the chemically active reservoir terms—supplied by the decomposition of the source gases which have diffused upward from the troposphere—in the middle and upper stratosphere. The disappearance of the fluorocarbons to a firm approximation is matched by the appearance of the chemically active forms of chlorine in the middle and upper stratosphere.

Point 4: The chlorine constituents which enter as catalytic partners in the major ozone destruction cycle are Cl and ClO. Are these species present in the stratosphere—in the proper altitude interval—in amounts comparable to that required to provide a rate of ozone destruction commensurate with current model predictions?

Two independent techniques, one in situ and one remote, have been successfully used by three independent research groups to detect the existence and absolute concentration of ClO in the stratosphere. An in situ method has been used to detect the atomic chlorine fragment in the stratosphere. The work has been critically examined in the aforementioned WMO/NASA review.

To summarize, we single out observational evidence on the ClO radical, for it controls the rate at which the catalytic cycle is completed. Observations of ClO have defined the mean ClO concentration to a plus or minus 50 percent as a function of altitude at midlatitudes. The results demonstrate not only that the catalytic cycle takes place but also that it occurs with a frequency comparable to that predicted by current computer models.

Point 5: Have atmospheric observations proven in a scientific sense that the release of fluorocarbons at the Earth's surface results in the reduction of ozone in the stratosphere?

Isolation of cause and effect in any natural system is notoriously difficult to establish, and serious scientific observations of the photochemical structure of the stratosphere are in their infancy. The library of scientific data on this subject refers, in large measure, to midlatitude northern hemisphere studies; yet, what we confront is a question of global scale.

In addition, the atmosphere is by nature a highly variable system which defies simplistic conclusions. On occasion, observations present an unfathomable picture, as in the study of any natural system, which cannot be summarily dismissed but which must be interpreted with care.

Based upon observational evidence obtained in the last few years, we can answer with significant confidence a limited set of important questions, as reviewed above. What has not been demonstrated is that our description of the chemical structure of the stratosphere is complete, even for the restricted question of chlorine-induced ozone depletion. But as any unbiased critic would confirm, important steps have been taken toward defining the probability that chlorine will alter the global distribution of stratospheric ozone. A detailed account of this case appears, as I have mentioned more than once before, in the WMO/NASA document.

It is important to remember that the existence of ozone in the stratosphere relies on a dynamic balance between photochemical processes which both produce and destroy ozone. Considering both the delicacy of this balance—which provides our only protection against solar near ultraviolet radiation—and our routine synthesis and release of chemicals not present during the evolution of the atmosphere, our scientific understanding of the stratosphere is extremely immature. We have but a rudimentary grasp of the relationship between global transport processes, radiation, and photochemistry. Experience with similar chemical systems in the laboratory where we have the luxury of systematically establishing cause and effect through isolation and repetition has taught us repeatedly that chemical processes are often not what they appear to be.

In summary, what has been demonstrated through observations of the Earth's troposphere and stratosphere is that (1) a majority of the chlorofluorocarbon 11 and 12 released at the Earth's surface enters the stratosphere; (2) a major portion of the chlorine contained in those synthetic molecules enter the "reservoir" of total stratospheric chlorine; (3) the fraction of that total chlorine which exists as ClO and thus controls the frequency of the catalytic cycle in the stratosphere is an observable quantity; and (4) the observed concentration of ClO—at midlatitudes only—based upon two independent techniques, demonstrates that the loss side of the ozone ledger would be amplified by an amount corresponding to a column depletion of ozone at steady state—that is, in approximately the year 2020, given current release rates—of approximately 10 percent, and that this depletion will take place unless a mechanism can be found which balances the loss.

Thank you.

Senator GORTON. Dr. Anderson, I thank you very much for that statement.

We will now go to the last member of the panel, Dr. Clark.

STATEMENT OF EDWIN H. CLARK

Dr. CLARK. Thank you, Mr. Chairman, Senator Baucus.

I am Edwin H. Clark, Acting Assistant Administrator for Pesticides and Toxic Substances of the EPA. With me is Dr. Herbert Wiser, Director of the Stratospheric Modification Impact Research and Assessment Program in EPA's Office of Research and Development. We are pleased to appear before you today to discuss EPA's activities with respect to the chlorofluorocarbons.

With your permission, I would like to submit the written testimony for the record and will summarize it at this time.

EPA has depended mostly on the scientific analysis which you have already heard described and particularly as summarized in reports done by the National Academy of Sciences in the mid-1970's and some reports in 1979. We have another report which we are expecting now in December of 1981 to be done by the Academy again summarizing the current status of scientific understanding of ozone depletion.

Most of our activities and policies have been based on these reports. I should make perhaps two summary comments on them.

One is that the estimates of ozone depletion have fluctuated greatly over the years between 1974 and 1981, although they have been within a range of 5 to 20 percent.

Second, we are still unable to predict with confidence an ozone depletion level given the complexity of the atmosphere reactions and the current sparsity of monitoring data to validate results.

We also have some uncertainty with respect to the estimated effects of ozone depletion. As you know, ozone filters out most of the incident biologically damaging solar UV-B radiation. The role of this radiation in causing some forms of nonmelanoma skin cancer is well known through animal laboratory and epidemiological studies. But the correlation between this exposure and an increase in nonmelanoma skin cancer as a function of stratospheric ozone decrease can only be estimated, based on numerous assumptions. In the United States there are approximately 300,000 cases of nonmelanoma skin cancer a year.

Adequate definitive knowledge does not exist that identifies the relationship between this type of radiation and melanoma skin cancer, which is frequently fatal. However, such radiation may be one of the causative factors. There are about 6,000 fatalities per year from melanoma skin cancer in the United States.

There is also limited and imprecise data on the biological effects of such radiation. It may affect crop yields, aquatic plants, fish, and other biota, especially in the natural environment where organisms may have the capabilities to adapt to small increases in this radiation. But more studies are needed on this.

We are now sponsoring some selected studies on field studies to try to validate some of the laboratory work that has already been done.

Total CFC production and use has changed dramatically in the last decade in the United States. In the United States, a sharp drop in CFC production followed a peak of over 1 billion pounds in 1974. Recently the use of this leveled off to about 835 million pounds in 1980.

This general decline is the result of a large decrease in aerosol use of CFC's, which dropped from about 500 million pounds in 1974 to less than 25 million pounds in each of the last 2 years. This was accompanied by a significant increase in nonaerosol CFC use during the same period. Recovery of the construction and automobile industries combined with expected market growth in the use of CFC's for solvents, food freezing, and other applications may lead to an eventual increase in production over the 1974 peak.

Senator **Gorton**. Dr. Clark, if I may, I will interrupt your testimony at this point and simply include it in the record.

We now have been called for a vote. I have one or two questions which I would like to ask, and perhaps Senator Baucus does as well.

Senator **Baucus**. Maybe we can ask the questions before the vote. I just have one or two.

Senator **Gorton**. I have one or two as well. We will try to do that.

Dr. Molina, during the years since you and Professor Rowland advanced the ozone depletion measure, have you discovered any theory which has caused you to question your original theory about the depletion of ozone in the atmosphere?

Dr. **Molina**. Not really. Of course, we acknowledqe there are uncertainties. But we haven't acknowledged any basic reason to doubt the validity of the theory. There are, obviously, adjustments. But I think the basic premises are still valid as far as I see them.

Senator **Gorton**. How long is it going to take before we can verify your theory by actual measurement? I put that in the context of the fact that probably the next time we will deal with the Clean Air Act may be in another 5 years. How much more knowledge, how much surer are we going to be of ourselves 5 years from today?

Dr. **Molina**. That is a matter of judgment. It is just a matter of degree. I don't think 5 years will be, say, crucial, so by that time we will be able to tell for sure yes or no. We will always know more, but I would perhaps rather say that we would have to wait 10 or 20 years before we can actually be absolutely sure from an extremely skeptical point of view.

I could take the other extreme, and from my point of view we have already enough evidence to make a very strong case, that the theory is valid and possible.

Senator **Gorton**. Does any other member of the panel substantially disagree with that answer?

The record will show that no one spoke up on that one.

Because of the lack of really good measuring techniques, there have been various estimates of potential losses in ozone of somewhere between 5 percent and 20 percent in a measurable period of time, given no change in our habits. How significant is the difference between those two figures, if it were 5 percent as opposed to if it were 20 percent?

Dr. **Molina**. Again, I think this is a matter of judgment. I could answer that as not really a scientist but just a value judgment point of view.

To me, 5 percent is already too large a risk to take, if it is going to happen—it is not happening right now—but if it is something we are committing ourselves to do, with the continued release. So I don't think it is that significant from the point of view of regulations. We don't know whether we will find that it is going to be 5 percent or 10 percent. I think from the point of view of my personal point of view, both figures should still lead to some sort of regulatory action.

Senator GORTON. Does any other member of the panel wish to comment on that question?

Dr. ANDERSON. Mr. Chairman, I believe the panel on the medical impacts of a change in total common ozone perhaps should speak to this. You have called together a panel of chemists and physicists here.

Senator BAUCUS. I was going to ask the same question. I know the medical panel will follow yours, but you are scientists and you have studied the ozone problem. I wonder whether you have any view as to the urgency of any regulatory action.

Mr. WISER. Senator, some of the research sponsored by the EPA on plants, fish, and other nonhuman organisms shows that we don't have quantitative data yet, but some of the organisms may not be affected or are affected to a small degree with increased UV-B corresponding to a few percent decrease in ozone. We are really trying to get better data out of that now. So there is a possibility that for whatever reason, adaptation or any other reason, a few percent decrease may be let's say tolerable or acceptable as far as nonhumans are concerned. We cannot say quantitatively what the threshold would be for acceptability. We do know that we are going after this and that therefore the impact may be nonlinear; and therefore, for large decreases, there may be other answers. But for small predicted or estimated decreases perhaps some of the major organisms may be able to protect themselves or adapt.

Senator BAUCUS. Does anyone on the panel have any significant opinion or view as to whether the Congress should or should not set up any kind of regulatory process?

Senator GORTON. Now.

Senator BAUCUS. Now.

Senator GORTON. This year.

Senator BAUCUS. You care or don't you care? I am just curious.

Dr. ANDERSON. I would state one point of view, and that is that we were told specifically we would not be asked that question.

Senator BAUCUS. I am asking it. I didn't tell you that.

Dr. ANDERSON. I am sure you didn't. I would just point out that we would in a personal sense of course be delighted to respond to that.

Senator BAUCUS. Individually, your personal view.

Dr. ANDERSON. I know from my point of view, since I am engaged in the observation of the stratosphere, it is very crucial that a balance be maintained. Since the taxpayers are funding the research—I feel this very strongly—that it is a question that shouldn't be answered in that form. I don't like to dodge the question, but that is the basis for not responding.

Dr. MOLINA. Maybe I can just add a comment to that one. Again, I am talking as a person and not really a scientist.

It is a value judgment. But as a scientist, if I am simply thinking of—and repeating my statement—the possibility of perturbing a major natural cycle and a means that can actually avoid it without very major economic losses, then we would really be justified to actually enforce some sort of regulations.

I am not talking about an outright ban tomorrow on all CFC uses. There are many other uses that the National Academy of

Sciences has discussed. Personally I do feel very strongly about that.

Senator BAUCUS. Thank you very much.

Senator GORTON. We may submit a few additional questions to some of you in writing to which we hope you will respond. We should like very much to thank you for your willingness to assist us in this quite important query. So this panel is closed.

[A response from Mr. Molina to questions from Senator Simpson follows:]

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August 3, 1981

AUG 7 1981

Hon. Alan K. Simpson
U.S. Senate
Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Simpson:

I am writing to answer your questions in connection with the hearing of July 23 on the effects of chlorofluorocarbons on stratospheric ozone.

1. Question: Does your model or other models take into account the influx of space dust and decomposition products of meteorites when computing ozone depletion?

   Answer: I have indeed considered the question of influx of space dust and decomposition products of meteorites in connection with stratospheric ozone depletion, and my conclusions agree with those of most leading experts in the field: the effects should be small, and it is not worthwhile at present to incorporate them into detailed models of stratospheric photochemistry. The available experimental evidence supports this view: the measurements of free gas-phase Cl atoms and ClO and HCl molecules in the stratosphere agree reasonably well with model predictions; the amount of chloride found in particulates is rather small; etc.

   In contrast to this view, a recent paper by E. Murad et al. (Nature, 289, 273, 1981) suggests that the effect of metals from meteorites in stratospheric chlorine chemistry is quite substantial. Admitedly, more measurements in the laboratory and in the stratosphere will be necessary to thoroughly establish the importance of the effect, but the problem is not really of high priority according to most informed scientists dealing with stratospheric ozone. There are some forthcoming publications which will discuss this question in detail from a technical point of view, e.g., one by F.S. Rowland and P. Rogers of the University of California, Irvine, with the same conclusions that I arrive at, namely, that the effect of sodium or other netals of meteoritic origin on the chemistry of ozone in the stratosphere should be rather small.

2. Question: You mention that quantities of CFM's are measureable and increasing. What about ozone measurements -- is there precise data that shows ozone depletion in the worldwide atmospheric reservoir (in the stratosphere)?

Answer: There are at present no precise data showing that the total ozone column abundance has changed. The consensus is that the measurements are certainly consistent with the CFM - ozone depletion theory, since the predicted current depletion levels are not large enough to be observable, and since factors other than CFM's have to be taken into account, e.g., ozone production in the lower atmosphere by the so called "smog reactions" resulting from commercial aircraft. The consensus I mentioned above is perhaps best exemplified by the joint World Meteorological Organization (WMO)/United States Agencies Workshop report cited in the testimony by Dr. L.R. Greenwood of NASA, on July 23.

On the other hand, there are now some ozone measurements which indicate ozone depletion in the worldwide atmospheric reservoir, in the upper stratosphere, as predicted by the CFM - ozone depletion theory. These measurements were discussed by Dr. D.H. Heath of NASA/Goddard Space Flight Center at the recent WMO/U.S. Agencies Workshop mentioned above.

Sincerely,

Mario J. Molina

Mario J. Molina
Associate Professor of Chemistry

MJM:scg

Senator GORTON. Will the next panel come up to the front table? Senator Baucus and I will be back as quickly as possible, we hope within 15 minutes.

[Brief recess.]

Senator GORTON. The committee will come to order.

I apologize for the delay which we have caused each of you. I will repeat my hope that to the extent the witnesses can do so, that they summarize their written testimony, and it will be included in the record.

For this panel we will start with Dr. Setlow.

STATEMENTS OF RICHARD SETLOW, BROOKHAVEN NATIONAL LABORATORY, UPTON, N.Y.; JOHN PARRISH, DEPARTMENT OF DERMATOLOGY, HARVARD MEDICAL SCHOOL, MASSACHUSETTS GENERAL HOSPITAL, BOSTON, MASS.; FREDERICK URBACH, PROFESSOR AND CHAIRMAN, DEPARTMENT OF DERMATOLOGY, TEMPLE UNIVERSITY SCHOOL OF MEDICINE, DIRECTOR, CENTER FOR PHOTOBIOLOGY, SKIN AND CANCER HOSPITAL, PHILADELPHIA, PA.; MYRON UMAN, ENVIRONMENTAL STUDIES CONFERENCE, ASSEMBLY ON NATURAL RESOURCES, NATIONAL ACADEMY OF SCIENCES, WASHINGTON, D.C.; AND ALAN S. MILLER, NATURAL RESOURCES DEFENSE COUNCIL, WASHINGTON, D.C., ACCOMPANIED BY KARIM AHMED, STAFF SCIENTIST

Dr. SETLOW. Thank you, Mr. Chairman.

I am here as a Senior Biophysicist at the Brookhaven National Laboratory, and I was Chairman of the National Academy of Sciences Climatic Impact Committee Panel on Biological and Medical Effects of Supersonic Flight. I am also the present Chairman of the National Academy of Sciences Committee on the Biological Effects of Increased Solar Ultraviolet Radiation. You will hear more about this committee from Myron Uman.

The committee is concerned with approaches to four key questions, and when I mention these questions, you will understand that the answers are not in hand.

One. What is the relationship between dose and response for single wavelengths in the UV-B region?

Two. Do low intensities for long times give the same result as high intensities for a short time?

Three. What is the relative efficiency of different isolated wavelengths in producing observed biological effects? A knowledge of this so-called action spectrum is the key to making predictions.

Four. Is the sum of the effects of isolated wavelengths additive, antagonistic, or synergistic?

Unfortunately, the approach to estimating human health effects cannot take the direct experimental attack but must utilize existing epidemiological information and basic knowledge on the responses of cells to UV and the abilities of cells to repair radiation damage to their genetic material, so-called DNA.

The biological effects resulting from a change in ozone depend critically on the shape and the location of the so-called biological sensitivity curve. If this curve is not known from direct experiment or cogent theory—and we do have biological theories—there is no basis for making a prediction.

The action spectrum often used is typical of those representing the effects on the genetic material and has been found to hold for the killing of mammalian cells, mutation of mammalian cells, and transformation of mammalian cells.

Let me quickly get on to the meat of what you are interested in, and the other speakers will give more information on this subject: nonmelanoma skin cancer.

It is the most common of all cancers in the United States. It has an incidence probably of over 400,000 per year. But because of its low mortality, it is not a serious disease for the great majority of the people. Nevertheless, it does worry individuals and it incurs health costs because of the need for continued checkups.

This type of skin cancer appears primarily on high-light exposed areas of skin, increases dramatically with age, and increases markedly as one goes further south. There is a wealth of experimental data indicating that the wavelengths responsible for such cancer are in the UV-B region and that a biological type analysis would give an increase of approximately 40 percent in nonmelanoma skin cancer for a 10-percent ozone depletion. Some estimates are as low as 20 percent increase; some as high as 80 percent increase.

For the more serious disease, malignant melanoma, the data I quote come from the National Academy of Sciences report issued in 1979, which indicated that the 5-year survival rate for this disease was between 65 and 70 percent and that the number of new cases in the United States was close to 14,000 per year, with a death rate close to 4,500 per year. Thus, it is a relatively rare disease, but its incidence has been increasing with time, in the United States at the rate of several percent per year and in Norway at about 7 percent per year for the last 20 years.

Because melanoma does not appear on the areas of the skin that are exposed to the highest light intensities, nor is it a disease associated with outside occupational exposure as is nonmelanoma skin cancer, and the latitude gradient is not as steep as it is for nonmelanoma skin cancer, there is serious uncertainty as to the role of sunlight exposure in melanoma incidence.

On the other hand, the following arguments indicate that sunlight and UV-B are important in melanoma incidence:

First, it is primarily confined to light exposed areas, especially considering the scanty bathing suits now in general use.

Second, melanoma's increase with time is not mimicked by ocular melanoma, a melanoma in tissue of the eye, which though exposed to light is shielded from UV-B by the absorption by the intraocular fluid.

Third, melanoma appears with an extraordinarily high prevalence in individuals who are defective in repairing UV damage to their DNA—individuals with the disease called xeroderma pigmentosum. Hence, the overall evidence is ambiguous but indicates that more than just the cumulative exposure to UV-B is involved in melanoma.

Let me summarize briefly. Both experiment and theory associate nonmelanoma skin cancer closely with exposure to UV-B. The disease affects large numbers of people but is readily cured. The causal connection between UV-B and melanoma is not strong but, on the other hand, it is not weak. Melanoma is a serious disease and affects relatively small numbers of people. A 10-percent ozone decrease is estimated to give a 40-percent increase in nonmelanoma cancer incidence and a 30-percent increase in melanoma incidence.

Thank you, Mr. Chairman.

Senator **Gorton**. Thank you very much, Dr. Setlow.

We will proceed to Dr. Parrish.

STATEMENT OF DR. JOHN PARRISH

Dr. **Parrish**. Mr. Chairman, thank you for the opportunity to address your committee.

My name is John Parrish. I am associate director of Dermatology at the Harvard Medical School and the director of the Weldon Medical Photo School at Massachusetts General Hospital. We study the effect of ultraviolet radiation on intact human living beings, especially their skin and blood.

Humans, like most life forms, live in a curious balance with the Sun. They are totally dependent on the Sun. Yet the photosensitivity it provides is necessary for life and vision by stimulating photochemistry in the retina. Yet, the ultraviolet component of the Sun harms or kills cells in living humans.

The existence of the ozone layer provides protection from ultraviolet radiation. It omits largely the short wavelength and decreases the biological activity of UV-B.

Most complex life forms have further developed other means of protection, pigments or avoidance responses or intelligence, that allows them to further decrease ultraviolet radiation.

I think it is fair to say that decreased ozone will increase ultraviolet radiation and therefore increase biological hazards. The magnitudes, unfortunately are uncertain.

Any increase in ultraviolet radiation will cause a direct effect on humans. There will be many indirect effects through the ecology but also some direct effects. The direct effects will be on human skin, the eye, and the immune system.

As to the skin, the risks are primarily sunburn, which is an inflammatory response to injury of cells within the skin, so-called premature aging, or actinic generation, which is a change in the connective tissue of the skin from chronic cumulative insult from the Sun, ultraviolet, and other wave bends, and increase in the incidence of skin cancer, which is clearly related to ultraviolet radiation.

In the eye, the risk of ultraviolet radiation, the acute risk, is conjunctivitis, which is usually avoided because we have physiological ultraviolet responses, which are not to look at bright lights or bright Sun. There is evidence that chronic ultraviolet radiation may play some role in cataracts.

Recently we discovered ultraviolet radiation affects the immune system of human beings, and particularly their ability to fight infection or to combat certain disease processes.

The optical properties of the skin are such that ultraviolet radiation enters into the skin and then enters into the blood of human beings. In fact, about 95 percent of the radiation from the visible rays that come back to your eye that looks at the Sun has actually entered through the skin and gone to the tissues. The blood flow of the skin is such that about 10 percent of your blood is in your skin at any one time. This is because the blood flow of the skin is primarily there for heat regulatory purposes. You have about 30 or 40 times the blood to feed your blood vessels present to regulate the heat of your body. This means a large proportion of the blood is available for radiation.

We have shown in the laboratory that the immune system is affected by ultraviolet exposures. After a sunburn dose of radiation, the performance, the viability of the function of white blood cells, the ability to have certain allergic responses in the skin, skin graph projection, and other ways we can measure immune responses in the skin and in the blood are altered by ultraviolet radiation in intact living humans.

All ultraviolet is not the same. The shorter wavelength ultraviolet, which are the wavelengths primarily affected by ozone, is much more efficient in causing some of these processes that we have discussed. Also, we must remember that all skin is not the same, that there are two principal photobiologic barriers or optical barriers to prevent the skin from being damaged by ultraviolet radiation.

One is a protein barrier, which is caused by protein in the outer layer of skin, which can be increased by ultraviolet radiation. That is pretty much the same in all humans.

Another barrier is a pigment barrier, melanin, which can also be increased by ultraviolet radiation. This is definitely not the same in all individuals. Both the base melanin pigmentation and the ability to increase that pigmentation is genetically controlled and varies greatly from person to person.

There are two additional barriers. One is sunscreens. There are many very, very good sunscreens that decrease the amount of ultraviolet radiation hitting the skin. The other is the human brain. We can use our intelligence to avoid the Sun and avoid long ultraviolet radiation. I would like to very briefly give some perspective about this.

A decrease in the ozone layer does two things to ultraviolet radiation. One is it increases the absolute amount, but also it changes the spectrum. It shifts the spectrum toward shorter wavelengths. As you heard, these are more effective at causing biological phenomenon.

When we think also about avoiding sunburn we must remember that avoiding sunburn does not give us any reassurance that cell injury hasn't occurred in the skin. There is evidence that DNA is damaged in the skin, that individual cells can be killed, that melanocytes or pigment cells can be altered and there are some cumulative effects which occur in the skin, all at less than sunburn-producing doses. So avoiding sunburn is not necessarily reassuring we have avoided cell damage, which may lead to skin cancer and premature aging.

We also found out, as Dr. Urbach will elaborate, that the effect of ultraviolet radiation in causing skin cancer is very complex. They are not simple formulas related to total dose of radiation. It has to do with intermittency of hits, the intensity, and the chemicals in our environment that can alter the susceptibility of the skin. And there are many other factors. This is also true for aging of the skin and for the immune responses.

As a physician, I would say that the increase of ultraviolet radiation which may occur from ozone depletion and the shift in the spectrum which may occur from ozone depletion will have effects on the skin, eye, and the immune system which are really a greater threat to white people than to black people, which are very difficult for us to quantify, and which are probably small compared to the capacity or the willingness of humans to compensate. That is, by the use of good sunscreens you can decrease the ultraviolet radiation by a factor of 20. This is much greater than any effect we will see from the ozone shift. And by the use of the human brain it is possible to decrease ultraviolet radiation further by altering our habits as far as sun exposure. But there again, the willingness of humans may exceed their capacity.

As a biologist I will say in closing that I think the hazard to our ecology is also very real. I think it is mostly unknown. We cannot gather all the information necessary to make good equations about the size of the risk to our ecology. In 5 years I don't think we will still have all the information. These hazards may exceed our ability to compensate. So, Mr. Chairman, I would say that the solar spectrum as we know it now was determined over millions of years. It allowed expansive evolutions over hundreds of millions of years. And I think humans may be very bold to significantly alter that spectrum in a few hundred years. I think there may be some ecological surprises in there for us somewhere—some algaes, some marine forms, some delicate interdependent balance that may be destroyed. I think this kind of threat to our ecology may exceed the threat to our skin.

Thank you.

Senator GORTON. Dr. Parrish, thank you very much for your help.

Our third witness will be Dr. Urbach.

STATEMENT OF DR. FREDERICK URBACH

Dr. URBACH. Thank you very much, Mr. Chairman. My name is Frederick Urbach. I am director of the Center for Photobiology and professor and chairman of the Department of Dermatology at the Skin and Cancer Hospital at Temple University in Philadelphia. I am also a former president of the American Society of Photobiology and presently am president of the International Society, Associate Internationale.

You have heard most of the things that I have addressed in my commentary, which has been submitted to you, from Dr. Setlow and Dr. Parrish. I would like to add several points to this.

Incidentally, my interest in photocarcinogenesis dates back over 30 years now, having studied both experimentally and humans, particularly the effect of ultraviolet radiation on skin cancer.

There is, I think, no reasonable reason to doubt that the so-called nonmelanoma skin cancers, the majority of which fall into two categories, are primarily due to chronically depleted exposure to ultraviolet radiation of shorter than 329 manometer UV-B.

I don't think it has been pointed out enough, although Dr. Parrish commented on this, that the absorption spectrum is such it absorbs just a short end which is biologically most efficient or, if you like, most destructive, depending on how you like to look at it, and is absorbed by living materials of all kinds and does damage to all kinds of components, including the genetic ones.

It again must be pointed out if the ozone layer significantly decreases, there not only will be an increase in this particular portion of the radiation but a shift to other wavelengths, which is potentially more damaging.

The problem as far as human skin cancer, of course, is that while we are quite certain from all sorts of environmental evidence that some forms of cancer are chronic due to chronically repeated exposure, this type of tumor, however, only appears in certain humans. This is a disease primarily of white-skinned people, as Dr. Parrish said. It is extremely uncommon in blacks. It is very unusual in Chinese, Japanese, et cetera. A small amount of pigmentation protects one very well. So we are limited as to the number.

Among white people, there are big differences in the ability to respond, the exact number of which we don't know. But we do know that there is really perhaps in the United States 15 or 20 percent of the population that account for most of the nonmelanoma skin cancers.

One of the recommendations among those that are in the material I submitted to you is to study this sort of thing, because again, it is not everyone who will be at risk.

The second point has been addressed by Dr. Setlow. From animal experimentation it has become obvious that it isn't just a question of cumulative dose, the amount of ultraviolet radiation in this field that will respond in skin cancer. We can produce the cancer like in humans, with ease in mice, which seem to behave exactly like man.

It also depends on the rate at which the radiation is given and the frequency, the interval. Since humans are not exposed to ultraviolet radiation as a light source, as we have up here, for continually 8 hours, and the intensity of ultraviolet radiation changes each day dramatically from sunrise to sunset, it makes a great deal of difference whether one is exposed for an hour at noon or an hour at 9 a.m. or 4 p.m. Two thirds of this damaging radiation reaches us between 10 a.m. and 2 p.m. local standard time, 11 to 3 daylight savings time. The Sun doesn't know we goofed things up. It makes a tremendous difference.

These kinds of things we have begun to explore in animals but have not really explored also the changes in spectrum that occur because of the change in some angles. So it isn't only intensity. All of these things are important when people are exposed.

Let me give you another problem that we have run into. We have, a number of us, together with the Irish Cancer Society in Norway, some years ago, and the American Cancer Society in Philadelphia, made an extensive effort to try to correlate outdoor exposure for human beings with the development of skin cancer. That is a chancey business. If anybody wants to know about it, I will tell you about it later.

Let me point out to you that among these two basic kinds of skin cancer, there are big differences. Nonmelanoma cancer seems to be primarily related to all radiation, except a few due to arsenic or X-rays or things like that. One-third of the basic carcinomas, which make up 60 percent of the cases, seem not to be related to ultraviolet radiation. The risks are very different.

For instance, in the study I referred to, which has been published, if you assume a heavily-pigmented, dark-skinned white person who has had 3 hours a week of outdoor exposure for 3 years, he would have a risk of one to develop the basic cancer. The light-skinned 70-year-old who burns easily and who has had 3 hours a day instead of 3 hours a week exposure has a risk 14 times as high for basic carcinoma. But for erythema carcinoma, his risk is 140 times as high.

This is reflected indeed in the latest studies from the National Cancer Institute, which has done very good epidemiological studies, the latest one not yet published.

The only reason for bringing all of this out is that we are being asked rather constantly as to what will happen if the ozone goes down by 5 percent; how many cases of skin cancer will there be in the year 2010, or whatever? Unfortunately, in some of the earlier monographs of the Academy of Sciences there were some 49,336.2, a ridiculous multiplation figure.

The answer is it is very difficult to estimate this under the very best of circumstances. We now have measurements, incidentally, off the solar ultraviolet radiation that is related, as far as we can tell, to skin cancer from instruments that were designed under the CREA and now are sponsored by EPA and which have been running for 7 years.

We have just looked at the data of 14 such stations that have continuously measured that ultraviolet radiation for the past 7 years. Apropos of the ozone, since the ultraviolet radiation is a direct reflection of what will happen to ozone, but filtered through the local exhaust, rain, and whatever, we have found that over those 7 years there has been no measurable change in those 14 stations on the average, minus .3 percent. We can tell from these we would be able to detect changes of either plus or minus 2 percent in ozone concentration. So this fits with the other data you have heard earlier today, that there has been at least over the past 7 years from these data no demonstrable change, although a change of less than 2 percent we would not have been able to detect.

I think I would just like to finish by saying that we have suggested, as I have submitted to you, a list of recommendations of studies that need to be made in order to answer the question that was asked earlier, I believe, by Mr. Baucus. That is, what happens 5 years from now? Will we have any more information?

I am sorry to report to you that I was a member of the first conference of the National Academy of Sciences in 1970 at that time of the CSET's. I testified before Senator Bumpers' committee in 1976 on this problem. This is now 1981. I dug out my testimony from 1976, and the recommendations I am giving you are the identical ones to what they were in 1971, for the very simple reason that while a tremendous amount of effort and work and money has been spent on stratospheric physics and all that, a minuscule amount of money has been spent on any kind of biological research.

If you want to know whether you ought to regulate based on science—and since, after all, I presume our concern is with living things on Earth—I am moved to recommend to the Congress that a quite small investment, as money goes these days, of perhaps $1 million a year 5 years from now would give you some answers. So far I am sorry to say the same recommendations 10 years later can be given to you because there hasn't been any significant progress because there hasn't been any significant support for investigative work.

Thank you.

Senator GORTON. Doctor, thank you very, very much for your help, and your written statement will also be included in the record.

Our next witness is Myron Uman. Please proceed, Mr. Uman.

STATEMENT OF MYRON UMAN

Mr. UMAN. Thank you very much.

My name is Myron Uman. I am Associate Executive Secretary of the Environmental Studies Board of the National Research Council, which is the operating arm of the National Academy of Sciences and National Academy of Engineering. I am also the senior staff officer responsible for the Academy's current study of the causes and effects of depletion of stratospheric ozone.

I have submitted prepared testimony, which is brief. If I may, I will summarize that testimony even more briefly. Attached to the testimony are details that describe the Academy's efforts in this area.

In April of this year, the EPA asked the Academy to provide assistance to the agency in carrying out its responsibilities under section 153(g) of the Clean Air Act, which requires the Administrator to report biennially to the appropriate committees of Congress on the results of studies and research conducted by EPA and other Federal agencies.

The Academy agreed to assist by providing the agency with assessments of the state of knowledge about ozone depletion and its effects, concentrating on changes in the state of knowledge since the preparation of the earlier Academy reports. Our report will be submitted to EPA by December 21 of this year so that EPA may in turn report to you on January 1, 1982.

Our work is divided into two parts. We have assembled a Committee on Chemistry and Physics of Ozone Depletion and a Committee on Biological Effects of Increased Solar Ultraviolet Radiation. I regret that the timing of our work is such that the Academy is unable to present its results at this time. We shall be happy to provide testimony to you early next year.

Thank you.

Senator GORTON. Thank you very much, Mr. Uman.

Our final witness will be Mr. Miller. Would you ~~also introduce~~ your associate, please?

STATEMENT OF ALAN S. MILLER

Mr. MILLER. Thank you, Senator.

I am Alan Miller, staff attorney with the National Resources Defense Council. I believe you are familiar with the Defense Council with other aspects of the Clean Air Act, so I will simply introduce Dr. Karim Ahmed, who is accompanying me today and who is a Ph. D. biochemist and staff scientist at NRDC. Dr. Ahmed is one of several staff members who works on issues associated with hazardous chemical control policies at a professional level.

I simply would like to indicate from our prepared testimony a few of the key points without going into it in light of the short time we have available.

NRDC has been involved in the CFC issue essentially since the theory was first originated. We filed the initial petitions with the FDA and the Consumer Product Safety Commission which ultimately led to regulations in 1977 banning the use of fluorocarbons in aerosol sprays.

Subsequently, we have remained involved actively in the issue and, for example, in 1978 we prepared a 12-country comparative study of fluorocarbon regulation funded by the German Government, the conclusions of which were presented at an international meeting of governments on the CFC problem held in Munich in December 1978.

Since that time we have remained concerned with the efforts at EPA to evolve further ozone protection policies.

I want to also begin by pointing out that while the issue of ozone protection is of great importance, the approach that Congress takes will have significant additional influence on similar issues of scientific uncertainty which are also coming before the Congress. I think that the committee should be alert to the fact that comparable problems are presented by such issues as acid rain and CO_2 which will also require difficult judgments about the appropriate balance of values, given implications for the economy, while basing decisions on significant scientific uncertainty.

I basically have four points to make. First, that the threat to the health and the environment is real and serious, although difficult to quantify. I think prior witnesses have indicated what some of the threats are. My testimony indicates this in a general outline fashion.

I have also submitted to the committee a copy of our detailed comments on EPA's advance notice of proposed rulemaking which further indicate, with substantial reference material, the nature of the threat to health and the environment.

It is worth emphasizing that there are three different types of risks involved. I have with me today on this panel several distinguished experts on the issue of health effects, particularly the concern about skin cancer. What has also been indicated is there are significant additional risks that should not go unexamined having to do with marine and agricultural productivity and climatic change. It is the last risk in particular which we believe to be of greatest concern, simply because our understanding of the stratosphere at this stage is so minimal. And because of the major perturbations which are potentially going to be introduced, we are taking a high-risk gamble by playing around with something that we really don't understand. In that respect I think I would agree very strongly with the conclusions of the prior witnesses.

However, your concern as members of this committee is whether perhaps there is some substantial difference between 5 percent or 20 percent as a difference in the range of ozone depletion. As far as our examination concludes, the difference is one between a disaster and a catastrophe.

Applying the percentage figures indicated by Dr. Setlow to the impact of 5-percent depletion, we are talking about 2,100 melanomas and in the neighborhood of 800 to 1,000 additional deaths per year. You are the ones who have to decide if that is a significant health risk. We would argue it is.

At the same time, we would emphasize that a 2- or 3-percent column ozone depletion change is a substantially higher change at high altitudes—a point made in Dr. Molina's testimony that I think deserves emphasis. So even a small change in column ozone means very significant changes in the upper atmosphere.

Second, it is clear that we can't wait for proof without risking substantial irreversible harm. Again, as part of your investigation of what policies are appropriate now you need to know how much better our information is likely to be in the next 5 to 10 years.

The most authoritative internationally accepted source that I could find was a March 1981 draft report of the Organization for Economic Cooperation and Development, prepared in the process which involved industry comments and participation.

The EPA comments on that draft, prepared just a few weeks ago, conclude that it is unlikely that ozone depletion would be observable within at least the next 10 years. I emphasize "at least." There is simply no way to know exactly when our knowledge of the upper atmosphere will be sufficient to answer that troubling question. There is simply no way to avoid making policy now that addresses the problem, because as fluorocarbons continue to be released, it will be increasingly difficult to reduce the threat.

The longer we wait, the higher the costs of regulation will become. I can't emphasize this strongly enough. Not only is the amount of CFC's increasing steadily—again a point made in the EPA testimony—but it will become more difficult, the more investment we make in equipment that uses CFC's, to change our economy gradually if we in fact discover conclusive evidence of ozone depletion. If we wait until that occurs, the costs will be considerably higher than if we gradually introduce regulation now.

In addition, there is a substantial banking of emissions taking place insofar as fluorocarbons are being included in insulation and rigid foams, which only release fluorocarbons over a period of time. Therefore, even if we were to wait for the evidence which has been recommended by industry, there will be substantial irreversible harm and much greater cost for regulation.

I want to turn briefly to the legislative framework, since your committee is called upon to make sweeping changes in the Clean Air Act which deals with ozone protection.

We think the current framework is the appropriate one to address the problem. First, section 157 in particular has a strong emphasis on human health. We think in fact that is where one has to begin.

Second, it gives latitude to EPA to decide whether in fact there is sufficient evidence. Obviously, there is a great deal of scientific complexity to the issue. If anything else, this hearing has demonstrated that. Therefore, I think it is important there be an administrative process with a latitude to assess the facts, to receive comments, and to make the best possible judgment.

Finally, it is a process that allows costs to be taken into account. EPA has been very sensitive to the question of the cost and economic implications for industry. Let there be no doubt about that. Our comments indicate at great length the conservativeness of the process as it is currently evolved. Those studies that have so far been done by the Rand Corp. give very low and affordable numbers for the cost of instituting a production cap in the proposal made in the advance notice of proposed rulemaking.

Substantial criticism has been advanced by industry of those comments. However, the fact remains that as our comments indicate, substantial overestimate factors were included as well. That is the kind of give-and-take process which I think is appropriate to an administrative rulemaking process and which should be continued under section 157.

Finally, I wanted to emphasize that EPA has not even proposed a rule. While the tremendous industry criticism that has been raised has suggested EPA is in some way committed to some form of regulation, that is not at all the case.

EPA issued an advance notice of proposed rulemaking asking for industry comment and public reaction to various possible alternative forms of regulation. As indicated before the House Small Business Committee on Antitrust last week, that process is still going on. More than 2,000 comments have been received. EPA has not yet decided whether it should issue a proposed rule. We think it would be ironic indeed if EPA were to have its jurisdiction curtailed because it went to the effort of asking for public reaction on various alternative forms of regulation.

The proposed amendments would regrettably revert our regulatory system to a requirement for a form of bodies-in-the-street regulation by emphasizing the need for actual evidence of ozone depletion. I believe that the evidence presented today makes clear that we cannot depend on such a rigid, preconditioned standard for instituting any form of regulation.

No one is insisting on any particular form of regulation. No one is suggesting that we should not be sensitive to the costs of regulation to industry. But, at the same time, it is clear that we are tampering with a highly fragile element of the global ecosystem.

EPA has responded cautiously to this important public health issue in our estimation. The basis for concern now is no less than in 1977 when you adopted the amendments which currently provide for regulation. In conclusion, we believe the law should not be changed.

~~Senator GORTON. Thank you,~~ Mr. Miller.

Dr. Urbach did recommend to us a fairly specific course of action. I would like to ask the two first witnesses, Dr. Setlow and Dr. Parrish, whether or not on the basis of their studies and knowledge in this area there should be a significant degree of Federal regulation to oversee CFC emissions, even though that would obviously have a measurable cost to the economy.

Dr. SETLOW. My personal opinion is that they should be regulated. It is true they will have a cost to the economy. I feel that the theory is good enough so that if they are not regulated they will also have a significant cost to the health of people and the Nation.

Senator **Gorton**. To what extent would you carry that regulation: a limitation to approximately the current amount of emissions, a significant lowering, or a ban?

Dr. **Setlow**. I would not make it a complete ban by any means. I think one has to understand, of course, that the problem is really an international problem. It really is not only a national problem. If we do that, ban it, and everyone else continues to use it, then we are sort of wasting our efforts. I think we have to lead the way, or someone has to lead the way, and no one else is at the moment.

Senator **Gorton**. Dr. Parrish?

Dr. **Parrish**. My expertise in regulatory affairs is small and goes down each year as I get more exposed.

It is a very difficult question because I think the ozone question may be considered a test case. Are we as humans able to elect not to use the most convenient and modern technology or the most economically competitive methodology in order to preserve our ecology? Eventually I think we must begin to make the concessions which yield more to ecologic concerns.

This is a very complex issue, the ozone question. I think we are at least at the stage now where we are beginning to ask good questions. The ozone question may not be the most important single critical question in this debate, but the use of good judgment in the whole ecology-technology balance, along with certain defense stances, I think will determine our very existence. So I think it may be a good test case, once we can begin to ask good questions and start to set up some regulatory guidelines where our ecologic interests may outstrip our technical side.

Dr. **Urbach**. Senator, I wasn't aware I commented on regulation in any way, shape or form. All I said is 5 years from now we wouldn't know any more than we do today scientifically unless somebody sponsored this. I don't know that has anything whatever to do with regulation.

But I would like to comment, if you will let me, briefly. I feel like Dr. Parrish. My knowledge of regulation gets worse and worse.

But the very difficult problem here is compared, for instance, to the ruin of Lake Erie. You can see the thing turn green and the fish die in a period of a few years.

We are dealing with a problem where it is quite clear from previous testimony if something is going to happen to the ozone layer, it will reflect itself to the point where we can measure it and feel the biologic effects a very long way down the pike—20, 30, 40 years from now, not in the next 5 years—because of this slowness of diffusion of these various products through the stratosphere, troposphere, et cetera.

This gets to be one of these biblical problems. This may affect our children. I don't mean to be funny in any way or means. I think that is the very difficult part to judge when we have certainly some information that chloro radicals will affect ozone. The changes in the degree of affection, unfortunately—as I said, I have been at this since 1970. The predicted changes in the amount of ozone, as you heard from the NASA people, have varied all over the map. They have gone up, down, and sideways. As late as 6 months ago a change in the rate constant again changed the prediction of the state of ozone depletion from chlorofluorocarbons.

Our problem here is the stratospheric chemistry is not as well changed.

As far as the biological effects are concerned, the reason nobody talks much about plants and so on is they know even less about that than skin cancer. We know very little about skin cancer.

I think in 5 years the effect on biologic systems, aquatic or plants or whatever, that 5 years from now there could be a very significant increase in knowledge, assuming that an organized effort was made with appropriate support to study this.

This is what makes the problem of regulation so difficult, you see. It would appear from the present emissions, from what little I understand—and I am no expert—waiting 5 years to regulate any further is not going to make a great deal of difference in the end stage. Whether it is going to be 5 or 20 percent, I don't know. But if we don't know any more 5 years from now, we might as well do it today.

Senator GORTON. Mr. Miller, it has been referred to here, and in your own testimony, that we are not dealing with a national but an international problem, and that in one sense we could regulate to a zero point and not have too great an impact on the worldwide emissions. How does that affect your own set of recommendations to us here in the Congress of the United States? Do you feel that by continuing our present regulatory regimen we are more likely to encourage an international approach to it, or that we would be more likely to encourage that international approach by saying we are going to do nothing until others do something?

Mr. MILLER. NRDC is in fact an internationally oriented organization with members in more than 20 countries. As my testimony indicates, we have directly participated in several international meetings. I think we have a somewhat unusually extensive record of involvement in the politics of the environment in other countries.

I have two basic responses to that issue. One is that the fact is that we are such a significant producer of CFC's and a user of CFC's that in fact unilateral action by the United States does in fact have a direct impact on the global situation. So it is not accurate, first of all, to characterize our efforts as being de minimis in the qlobal context.

Second, and perhaps more significantly, my sense of international environmental politics is that the international environmental scene is no different from the U.S. scene and that the actions that are taken here have a very significant influence. When the United States makes a decision to regulate, that is broadcast all around the world. Other governments want to know why. They become more interested themselves. The environmental ministries have to take note. It has in fact been very accurate, as the other witnesses have said, that the United States has exercised a significant leadership role.

If in fact we take the opposite position, if we cut back and curtail our regulation, that will signal the exact opposite position to the rest of the world. In the eyes of many foreign nations, we are in the best economic position to afford making these difficult regulatory decisions. We are the ones who use most CFC's for automobile air-conditioning, which is considered a tremendous luxury in

Europe. That is always the first thing that is said to me by French and British officials is, "Don't tell us to regulate. You are the ones throwing this stuff away in automobile air-conditioners." Therefore, they think we do have a responsibility to exercise a leadership role.

Now that doesn't mean we shouldn't work for international cooperation. As my testimony indicates in some detail, I think the U.S. efforts toward international cooperation have been commendable, and we hope that under the new administration they will continue. But the need for international cooperation should not in any way diminish our efforts to address the issue domestically.

Senator GORTON. Mr. Uman, do you wish to comment?

Mr. UMAN. I have no comment.

Senator GORTON. Then I should like to thank this panel for the enlightening testimony which it has presented. We have another rollcall vote.

[A response from Mr. Setlow to a question from Senator Simpson follows:]

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July 30, 1981

Miss Katherine Y. Cudlipp
Committee Council
Committee on Environment and Public Works
United States Senate
Washington, D. C. 20510

Dear Miss Cudlipp:

The answer to the question submitted by Senator Alan K. Simpson, "What increase in melanoma incidence would be caused by a 2% decrease in ozone" follows:

The percentage increase depends upon location. For example, the best estimate for Minneapolis would be 5.3% and the best estimate for Dallas-Ft. Worth would be 9.5%. Perhaps 7% would be a good average for the United States.

The above estimates are based upon data given in the National Academy of Science 1979 report "Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons." The estimates assume that the variation in incidence from place to place within the United States is determined by the average amount of ultraviolet radiation in sunlight that affects the genetic material of cells.

Sincerely yours,

R.B. Setlow

Richard B. Setlow

ls

Senator **Gorton**. Congressman Luken is here, I believe. What I would like to do is give him an opportunity to introduce the next panel, but I will not be able to start the panel until I have responded to that rollcall.

Congressman Luken, please come forward. You are welcome to this hearing. We would be happy to hear your introduction, subject to our own time constraints of running back to vote.

STATEMENT OF HON. THOMAS A. LUKEN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF OHIO

Mr. **Luken**. Thank you, Senator.

My name is Tom Luken. I am from Cincinnati, Ohio. I am a Member of the House of Representatives.

I have taken the liberty of asking your indulgence in introducing these gentlemen who have testified at a previous hearing in the House. They are Mr. Donald Lynch, Mr. John Norris, Charles Masten, Perry Culp, Ray Way, and Stephen Askew.

Senator **Gorton**. We are happy to have them here. We are happy to have you here. Do you wish to make any statement on the proposals which we have before us?

Mr. **Luken**. Yes, Senator. Do you want me to go ahead?

Senator **Gorton**. If you will. When I get my second buzzer, I think I am going to have to put the rest of your statement in the record. But go ahead for the moment.

Mr. **Luken**. All right. Senator, I am proud and privileged to appear before your Subcommittee on Toxic Substances and Environmental Oversight on the question of the EPA action in reference to chlorofluorocarbons, CFC's.

I have sponsored legislation in the House, H.R. 1853, to prevent EPA from moving any further on its ANPR until more studies can be completed on the validity of the ozone depletion theory. I think this legislation represents a logical and prudent directive for EPA to administer.

The ozone depletion theory warrants continued research and analysis. Its hypothesis should be seriously considered and studied by the scientific community. Though I have a nonscientific background and therefore I cannot argue the scientific reasoning and work to date, after listening to numerous scientific arguments, I have no doubt that there is wide disagreement about the validity of this theory.

Due to the seriousness of the ozone depletion theory, a resolution, we recognize, must be reached. That is the point. The theory must be proved or disproved, and to accomplish this requires further research.

Although tremendous gains in ozone knowledge have been made since the theory was first offered, all ozone depletion numbers cited to date are uncertain calculations from computer models. They are not measurements or observations.

Further, the factors which are the bases of these calculations are constantly changing as more knowledge is gained.

Analysis of actual measurement of ozone concentration shows no ozone depletion to date. If any trend does exist, it appears to be one of an increasing ozone layer. Therefore, from the scientific perspective, two important points emerge for why CFC regulations are unjustified at this time.

First, no consensus exists within the scientific community regarding the validity of the theory. Second, there is still much to be learned about the ozone before a consensus can actually be reached.

Senator GORTON. Congressman, I greatly apologize. I am going to have to interrupt. I must leave to cast this vote. We would be happy to have you remain, but, of course, since you are equally busy, we would be happy to simply put the balance of your statement in the record, whichever is your desire.

Mr. LUKEN. I will remain, Senator, of course subject to the same call. If you don't see me, you will know why.

Senator GORTON. All right.

[Brief recess.]

Senator GORTON. Congressman Luken was also called away to a vote. I understand he will return. Nevertheless, at this point we will put his statement in the record.

[The statement follows:]

STATEMENT OF

HONORABLE THOMAS A. LUKEN, M.C.

BEFORE THE SUBCOMMITTEE ON TOXIC SUBSTANCES AND ENVIRONMENTAL OVERSIGHT
SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

July 23, 1981

The current scientific information and analysis on the ozone depletion theory do not justify the need for E.P.A. regulations on chlorofluorocarbons (CFCs) especially in light of the economic costs of these regulations.

As you know, I sponsored legislation, HR 1653, to prevent E.P.A. from moving any further on its Advanced Notice of Proposed Rulemaking (ANPR) until more studies can be completed on the validity of the ozone depletion theory. This legislation represents a logical and prudent directive for E.P.A. to administer.

The ozone depletion theory warrents continued research and analysis; its hypothesis should be seriously considered and studied by the scientific community. Having a nonscientific background, I cannot argue the scientific reasoning and work to date; however, after listening to numerous scientists I have no doubt that there is wide disagreement about the validity of this theory. Due to the seriousness of the ozone depletion theory, a resolution of the debate must be reached; the theory must be proved or disproved. To accomplish this requires further research.

Although tremendous gains in ozone knowledge have been made since the theory was first offered, all ozone depletion numbers cited to date are uncertain calculations from computer "models." They are not measurements or observations. Furthermore, the factors which are the basis of these calculations are constantly changing as more knowledge is gained.

Analysis of actual measurement of ozone concentration show no ozone depletion to date. If any trend does exist, it appears to be one of an increasing ozone layer.

From the scientific perspective, two important points emerge for why CFC regulations are unjustified at this time: first, no consensus exists within the scientific community regarding the ozone depletion theory's validity; and secondly, there is still much to be learned about the ozone before a consensus will be reached.

Lacking this scientific consensus on the theory's validity, what are the risks of delaying any E.P.A. rulemaking on CFCs versus the risks of an immediate rulemaking? A major argument offered by those favoring immediate regulation is that the ozone problem is serious enough that no rulemaking delays should occur while further scientific study is underway; any delays means further ozone depletion which means further health dangers. However, the difference in ozone depletion , if the theory holds true and the National Academy of Science's analyses are valid, between immediate regulatory action and delayed rulemaking while current research is completed is minimal.

In addition an early warning system, ozone trend analysis, exists to detect change in the ozone concentration. Ozone trend analysis is a statistical analysis of actual ozone measurements capable of detecting 1.3 percent change in ozone concentration per decade from any cause. Such measurements and analyses are independent of the assumptions and uncertain estimates which have been made in order to perform the model calculations of theoretical ozone depletion. This early warning system reduces the risks of ozone depletion, if the theory proves valid, while scientific studies continue.

What are the risks of an immediate CFC rulemaking? The economic consequences of any regulations would be enormous because of the numerous and varied uses of CFCs. These consequences are more numerous and extensive than previously thought. By design, an E.P.A. rulemaking would increase CFC prices. Such price increases would not only be felt by the businesses using CFCs but by consumers as well. Within the business community, small business would bear the economic brunt of the regulations.

Last week the House Small Business Subcommittee which I chair held a eharing to address the impact of any CFC regulations on small business. One witness succinctly stated the opinion of small business when she stated the following: "The government is going to drive us out of business by issuing a regulation which is based on a theory that hasn't even been proven and for which many doubts exist."

The artifically induced higher prices and the potential inability of small businesses to acquire CFCs for essential uses could financially ruin many of these firms. In many cases either a CFC substitute does not exist or usage of the substitute would compromise worker safety and increase capital expenses.

Another witness from the Committee hearing I previously mentioned offers an example of these problems in addition to demonstrating a wide range of economic effects from CFC regulations. The witness operates a butcher shop which requires meat freezers. If CFCs become unavailable or become prohibitively costly, this man would be forced to change his refrigerants from CFCs to ammonia which is highly flammable and toxic. The switch would be at the expense of worker safety. However, more than worker safety is involved: switching from CFCs to ammonia requires changing the compression systems and other costly expenses. If the meat freezer is in need of new insulation and insulation is used that does not contain CFCs,which are the most efficient insulator, then more energy would be required to maintain the required freezer temperature. This situation does not contribute favorably to our nation's efforts to conserve energy, and the higher consumer prices that would be passed on to the consumer due to an increased energy bill do not contribute favorably to the nation's inflation problem

E.P.A. states that the current ANPR does not bind the agency to any set schedule of rulemaking nor even to a rulemaking itself. Yet letters and statements from E.P.A. clearly demonstrates that more regulations will be promulgated beyond this initial attempt of CFC production caps.

I recognize that different persons are now in E.P.A. policy making positions, that the issue is not an agency priority, and that the issue is under review by the Vice President's Regulatory Task Force. However, the question goes beyond the current ANPR; it involves future rulemaking as well.

If the ozone depletion theory proves valid, there is no doubt that immediate regulatory action will be necessary to prevent any serious harm to life and health. However, the theory has not been proved or disproved; no scientfic consensus has been reached; and further study is needed before conclusions can be drawn.

To enact regulations that will cause severe economic consequences on the basis of a theory that has not yet been proven or disproven is not responsible government. As studies are completed and more knowledge is gained, a resolution of the theory's validity will be forthcoming. With the risks of waiting being minimal even if the theory proves true, we can afford to wait until that time.

Senator GORTON. We are happy to be joined by our colleague, the distinguished Senator from Texas, who is a sponsor of a bill which is similar or identical to that of Congressman Luken. I will ask if you have an opening statement.

OPENING STATEMENT OF HON. LLOYD BENTSEN, U.S. SENATOR FROM THE STATE OF TEXAS

Senator BENTSEN. I just happen to have one.

First, Mr. Chairman, let me thank you for having these hearings and digging into the ozone depletion theory and the issue of controlling United States chlorofluorocarbon production.

We are all concerned about the growth of Federal regulation and its impact on the American economy. We have governmental regulations now costing over $100 billion a year. When you get that down to a figure you and I can understand, that is $500 for every man, woman, and child in this country. So we have to find a way to make regulations more cost effective and more balanced.

Today I think we are listening to testimony on where those efforts ought to be made. We are facing potential regulatory activity that clearly would have a major economic consequence that is not justified by the current state of the scientific data on the detection of ozone depletion.

For that reason, I introduced S. 517. It is designed to restructure research into ozone depletion detection and to revise regulatory activities related to the control of nonaerosol uses of CFC's.

Let me emphasize, this bill does not change any regulations involving the aerosol uses of CFC's.

Mr. Chairman, I have a very long and a very eloquent statement here. I will put it in the record in deference to these gentlemen, many of whom have traveled a long way to be here.

Senator GORTON. Thank you, Senator Bentsen.

[The statement follows:]

STATEMENT OF HON. LLOYD BENTSEN, U.S. SENATOR FROM THE STATE OF TEXAS

Mr. Chairman, first of all, I want to thank you for conducting this hearing on the ozone depletion theory and the issue of controlling United States chlorofluorocarbon production. We are all concerned about the growth of Federal regulation and its impact on the American economy. Government regulations are now estimated to cost over $100 billion per year. We must find a way to make regulatory activities more cost effective and balanced. Today, we are hearing testimony on an issue where just such an effort needs to made. We are facing potential regulatory activity that clearly would result in an economic consequence that is unjustified by the current state of the scientific data on the detection of ozone depletion. For this reason I introduced S.517--the Ozone Depletion Validation Act--which is designed to restructure research into ozone depletion detection and to revise regulatory activities related to the control of non-aerosol uses of CFCs. Let me emphasize that this bill does not change any regulations involving the aerosol uses of CFCs.

Mr. Chairman, CFCs are a family of extraordinarily useful chemicals that have a huge economic and social benefit to our Nation. These chemicals are an essential component to home, office, auto, and truck air conditioning; and to home and grocery store refrigeration. Let me say that in my part of the country air conditioning and refrigeration have moved from the category of luxuries to the category of almost necessities. Last year, when a massive heat wave embraced much of the United States, when temperatures consistently exceeded 100 degrees for 20 to 30 days in a row, about 2000 people died from the heat. Clearly, under that situation air conditioning can be a life and death propostion. CFCs are also important in certain types of food processing and insulation manufacture. They are used because they are safe and non-toxic to workers and consumers. Nationally, more than 780,000 jobs are related to CFC use.

In 1978, the Federal government banned the use of CFCs as aerosol propellants. It was an action based on a concern that CFCs reacted with ozone in the stratosphere. This 'ozone depletion theory' has yet to be confirmed by actual measurement of ozone levels in the stratosphere. Other nations have questioned whether controls of CFCs are now justified based on current scientific evidence.

Acting to ban the use of CFCs in aerosols in 1974 was a reasonable measure. Little was known about the magnitude of the problem and substitutes for the CFCs were available. However, the situation in 1981 is substantially different. In 1980, EPA proposed capping United States CFC production, creating artificial shortages and artificial competition for the available product--thus forcing prices up and limiting CFC availability for certain uses. The economic consequences of this proposal are especially serious for small businesses. Yet, all of these suggestions come at a time when the theory has not been confirmed by actual measurement and substitutes--safe and effective substitutes--are not available.

Mr. Chairman, this is a complicated issue that needs to be addressed in a more reasoned and balanced manner. My bill is designed to do just that. It revises the current research efforts to focus on actual detection of ozone depletion. It also restricts the regulation of non-aerosol uses of CFCs until either the detection efforts show that ozone depletion is beginning to occur at a rate which could be projected as potentially harmful or an international agreement is executed between CFC producing countries to regulate CFC emissions on a global basis.

I hope that today's hearing will provide the information needed to understand the scope and complexity of the ozone depletion/CFC regulation issue.

Senator GORTON. The first witness on this panel will be Donald Lynch from Prospect, Ky.

STATEMENTS OF DONALD LYNCH, GENERAL ELECTRIC CO.; JOHN W. NORRIS, JR., PRESIDENT, LENNOX INDUSTRIES, INC., DALLAS, TEX.; CHARLES N. MASTEN, DIRECTOR, FREON PRODUCTS, PETROCHEMICAL DEPARTMENT, E. I. du PONT de NEMOURS & CO., INC., WILMINGTON, DEL.; PERRY CULP, PRESIDENT, RMAX, INC., DALLAS, TEX.; RAY M. WAY, DIRECTOR OF TECHNOLOGY AND COMPLIANCE, CRESCENT MANUFACTURING CO., SEATTLE, WASH.; AND STEPHEN E. ASKEW, PRESIDENT, THERMAL PRODUCTS, INC., CERRITOS, CALIF.

Mr. LYNCH. First of all, I would like to thank Congressman Luken and Senator Bentsen for their fine support of what we consider to be necessary legislation.

Good afternoon. My name is Don Lynch. I represent the General Electric Co. I am here today on behalf of the Alliance for Responsible CFC policy.

The alliance is a coalition of over 500 users and producers of CFC's. Its members range from large, well-known companies to small, local businesses with few employees and limited resources. The alliance was formed last year after EPA announced that it planned to limit and eventually to phase down CFC production by as much as 70 percent.

The alliance believes that CFC regulation is not scientifically justified at this time and that the United States should therefore not be forced to give up the many benefits these products provide.

EPA's proposal to limit CFC production understates the scientific uncertainties and costs of regulation, downplays the important benefits of CFC's to our society, and ignores the conclusions of other governments that no further regulation is presently justified or necessary.

Against this background, the alliance strongly supports S. 517. The bill would require any further U.S. CFC regulation to be based on an international agreement about the need for regulation or on the actual detection of a developing problem with the ozone. We believe this bill is responsive to the environment and economically rational.

To fully appreciate the implications of EPA's proposal, and the need, therefore, for S. 517, there needs to be an understanding of the importance of CFC's.

CFC's are nonflammable, relatively nontoxic, chemically unreactive, and have excellent heat transfer properties. These qualities have made CFC's uniquely suitable for a wide variety of uses, some of which will be covered by the following speakers.

The largest use of CFC's is as refrigerant for refrigerators, freezers, and air-conditioning systems. Refrigeration is essential to food handling and storage.

Air-conditioning of homes, offices, factories, hospitals, and so on, is clearly essential to our society. An entire section of the country, the so-called Sunbelt, has grown in recent years in great measure because of the availability of air-conditioning. In addition, many important industries could not survive without air-conditioning as an integral part of their processing technology.

CFC's are also used in air-conditioning in automobiles and trucks; as closed-cell rigid foam for housing; flexible foams for padding for furniture and for seats in cars, trucks and aircraft, and packaging; special foam for professional packaging and industrial containers; special cleaning solvents for aerospace, computer and medical devices; liquid food freezants; and fire-retarding agents and sterilization.

For most CFC uses, practical substitutes are simply unavailable. Those substitutes that are available generally are more toxic or do not perform adequately.

In addition, any limitation on the availability of CFC's would have significant energy-related effects. A study conducted by Battelle Columbus Laboratory estimated that a complete ban of CFC's would result within 10 years in an annual increase in U.S. energy consumption equivalent to 226 million barrels of oil. That corresponds to about 43 percent of the current annual oil production from Alaska's North Slope.

There are other considerations as well. Although there are only five domestic producers of CFC's, there are thousands of downstream users. Moreover, most of the companies that use CFC's are small businesses. As a result, any program as proposed to ration CFC's would require these thousands of small businesses to compete with each other and with larger companies for the available supply, with questionable results.

In conclusion, CFC's are not an end product in and of themselves but, rather, a means to the end product, or a part of an end product. Thus, if the availability of CFC's is restricted, the impact would be felt primarily by all the users downstream—the 260,000 business locations that provide more than three-quarters of a million full-time jobs directly related to CFC use, and by the people and businesses that own or use the estimated $135 billion of already installed goods and equipment that are dependent upon CFC's for their operation.

In general, we believe the important societal use of CFC's requires valid evidence of potential ozone depletion before any regulation is considered. S. 517 would establish rational guidelines for action that would protect society both environmentally and economically.

Charles Masten will now speak on the science and the international situation.

Senator GORTON. Our second witness is Charles Masten of the Du Pont Co.

STATEMENT OF CHARLES N. MASTEN

Mr. MASTEN. My name is Chuck Masten. I am the director of the Freon products division of the Du Pont Co., one of five domestic producers of CFC's. The other producers in the United States are Allied, Penwalt, Kaiser, and Racon.

My remarks, Senator Gorton, will be in summary form.

Several points must be made about the ozone depletion theory.

First, it remains unvalidated.

Second, there remain significant uncertainties.

Third, and most importantly, there is now the ability, using a statistical technique known as ozone trend analysis, to treat actual measurements of ozone made around the world. It is sensitive enough to detect a change in ozone concentration of as small as 1.3 percent per decade. These analyses provide insight into the computer generated ozone depletion numbers that have caused so much concern.

For example, in 1979 the National Academy of Sciences reported that about 2.1-percent ozone depletion should have already occurred. However, ozone measurements taken around the world over the last 20 years have now been analyzed by three different groups in the United States and no ozone depletion has been detected from these analyses.

Understanding of the science has been rapidly changing since the 1979 NAS reports, and it is interesting to note that the most recent computer calculations indicate a theoretical ozone depletion only one-fourth the NAS 1979 prediction.

A fourth point is that all ozone depletion numbers available to date are computer calculations which are highly dependent upon numerous assumptions and estimates inadequate for regulatory decisions.

We believe that the uncertainties in the theory are large. Our underlying position has been that the theory should be investigated and that regulatory decisions should be based on the facts developed. To that end, the CFC producers' research arm, the Fluorocarbon Program Panel, has funded over $10 million of research on the issue at universities and independent labs. And many more millions have been spent on in-house research.

Another very important aspect of this controversy is that ozone depletion, if it occurs, would be a global problem because: First, the atmosphere doesn't recognize national boundaries. Therefore, no nation can unilaterally protect its overhead ozone layer. And second, CFC's are produced and used worldwide. Consequently, any meaningful action to protect stratospheric ozone, if required, must be global, not unilateral.

Yet, unilateral action has been EPA's basic approach. With its CFC aerosol ban, the U.S. already has gone far beyond action taken by any other major CFC producing or consuming country. In contrast, the European Economic Community has only reduced aerosol usage by 30 percent. Yet, EPA now proposes to undertake further unilateral U.S. regulation, arguing that such action would pressure other countries to follow suit. What is needed is international agreement on the facts, not regulatory example-setting.

At this juncture, we hope that the current EPA Administration will determine that further CFC regulation is not necessary at this time. However, we urge the Congress to carefully evaluate, and amend as necessary, the present extremely broad grant of statutory discretion to EPA concerning CFC's. We believe the present Congress needs to give clear direction to EPA on a proper and reasonable approach to resolving the many scientific and economic issues which continue to surround the ozone controversy.

We believe that enactment of S. 517 will accomplish this goal. Using ozone trend analysis as an umbrella of safety, further regulation can be deferred while research on the theory is continued, and work toward international understanding on the science, on the degree of risk and on equitable regulatory solutions can proceed.

We would now like to turn to testimony on four of the various CFC uses. More detail on these and the other CFC uses may be found in our written testimony.

Senator Gorton, I would like to add one thing. A number of the questions that were asked the other panels, the fluorocarbon panel, we could submit a paper to your committee that would put many of those answers in perspective as they see it.

Senator GORTON. We would be happy to receive that paper, and it will be included in the record. (See p. 248.)

Mr. MASTEN. Thank you.

Senator GORTON. Mr. Norris?

STATEMENT OF JOHN W. NORRIS, JR.

Mr. NORRIS. Good afternoon. My name is John Norris, Jr. I am president and chief executive officer of Lennox Industries of Dallas, Tex. We are a major manufacturer of central air conditioners and heat pumps which depend upon CFC's as the primary refrigerant for residential and commercial applications.

In 1977, the last year for which we have firm data, the U.S. air conditioning and refrigeration industry consisted of some 730,000 employees and 66,000 establishments doing $26.4 billion in domestic and export business annually. About 70 percent of the industry's employment and 98 percent of the business establishments are small contracting and distributing businesses in every city, town and village, in every State of the union.

I would note that the Small Business hearings held on July 15, 1981 by Congressman Luken produced in graphic detail the very real threat EPA's proposed CFC regulations would have on these small businesses. I commend the proceedings of that hearing to this committee.

Net exports of our products produce an annual positive contribution to our balance of trade of $1 billion per year. The EPA's regulation will immediately place that in jeopardy to Japanese, European and other manufacturers whose governments give no indication at the moment of agreeing with the EPA's evaluation that CFC's pose a threat to the environment.

My written comments which have been submitted for the record reference the huge number of essential air conditioning and refrigeration uses, all of which depend upon CFC's. Some were listed earlier by Mr. Lynch. In the interest of time, I would like to skip that and briefly discuss the alternative refrigerants now available to us, and the assumption that air conditioning and refrigeration is essential.

While there are at present several alternative chemicals which have usable thermodynamic properties that might be used to substitute for CFC refrigerants, these alternatives all have serious environmental, health, or energy penalties associated with them. Further, these substitutes cannot be used with any of the present installed equipment, all of which uses CFC's.

Sulfur dioxide and methyl chloride are toxic and/or corrosive. The hydrocarbons like butane, propane and their derivatives are dangerously explosive. Ammonia is toxic, corrosive and mildly flammable and has poor thermodynamic properties for applications other than low temperature, or subfreezing, work.

Air and carbon dioxide are not good substitutes for CFC's as they have poor thermodynamic properties for air conditioning and refrigeration and have very severe energy penalties requiring up to two times more energy to produce a given amount of cooling.

In conclusion, we find it unconscionable that EPA is pursuing a regulation with such clear adverse effects on the country's employment, health considerations, safety, balance of payments and energy consumption based on a theory which is at present unverified.

I would like to personally thank Senator Bentsen from my home State of Texas for introducing Senate Bill S. 517 and Senator Tower for cosponsoring the bill. We believe it would put EPA back on a rational course in examining this issue. I urge its adoption by the Congress with all due speed.

Thank you.

Our next speaker is Perry Culp, who will discuss rigid foams for home and commercial insulation.

Senator GORTON. Mr. Culp, you are welcome.

STATEMENT OF PERRY CULP

Mr. CULP. Thank you, Senator.

My name is Perry Culp. I am president of RMAX of Dallas, Tex. RMAX is a privately owned small business, employing 175 people. We manufacture rigid foam insulation products for use in the residential, commercial and agricultural markets. Currently we have two plant locations: One in Dallas and one in South Carolina. We have one under construction in Fernley, Nev., right next to Reno.

RMAX is just one of many small and large companies who manufacture rigid foam board insulation.

Our company is concerned about EPA's proposed regulations of CFC's for a variety of reasons, among them the fact that regulation may well spell the end of a valuable and useful product in the marketplace which is critical to energy conservation. The essence of these products is to trap and maintain the maximum amount of CFC gas. Because CFC's are the most effective way of retarding the transfer of heat, the more gas packaged within the cells of the plastic foam, the higher the insulation value. Think of our product as a bank vault to protect a valuable asset—energy-saving CFC's. If you outlaw the asset, you no longer need the vault.

In a time when energy concerns are critical, it certainly does not seem advisable to limit the supply of a product that does almost twice as good a job at preserving energy as anything else known to man.

Mr. Chairman, a proposed cap on the production of CFC's would, in my view, eventually mean the death of the foam insulating business. RMAX would be one of the first casualties. We have no other product to fall back on. The proposed cap would cause a scarcity of CFC's, driving up the price and creating severe supply uncertainty. The simple arithmetic of the situation is that energy conservation efforts would significantly diminish.

In closing, Mr. Chairman, we surely would not want to be put out of business by regulations based on an unproven scientific theory.

I would now like to introduce our next speaker, Ray Way, from Seattle, Wash.

Senator GORTON. I am very happy to have Mr. Way here from my home town. We will be delighted to hear from you, Mr. Way.

STATEMENT OF RAYMOND M. WAY

Mr. WAY. Thank you, Senator.

Good afternoon. My name is Raymond Way, director of Technology and Compliance for Crescent Manufacturing Co., of Seattle, Wash. Crescent is in the spice business. We use CFC as an inerting agent for the ethylene oxide fumigant used to eliminate harmful bacteria, such as salmonella, from spices.

Ethylene oxide is an extremely effective sterilizing agent. In its pure form, however, ethylene oxide is flammable and explosive. Therefore, its use is limited by safety, fire codes, zoning, insurance and economic considerations. However, when mixed with CFC, it is made nonflammable and nonexplosive while still retaining its sterilizing ability.

Over 40 percent of the spice we sell is to customers who require a reduction in the microbial content of the spices they purchase. This is because many spices as imported to the United States may be contaminated with such microorganisms.

I find it ironic that while we are trying to insure that our spice products are properly treated to lower the microbial loads therein, and the Food and Drug Administration has announced its intention to impose microbiological Quality standards for foods, including spices, and another Federal agency, the EPA, is threatening to reduce the availability of the very product which is essential to our ability to meet such standards, should they be imposed. It appears that we may be placed in a classic "Catch 22" situation.

We at Crescent urge you to support S. 517 which would insure that unnecessary regulation of CFC's not be enacted.

I would now like to introduce Steve Askew, our last panelist.

Senator GORTON. Mr. Askew, you may proceed.

STATEMENT OF STEPHEN E. ASKEW

Mr. ASKEW. Good afternoon. My name is Steve Askew. I am president of Thermal Products Co., of Cerritos, Calif. Thermal Products is a family-owned business, employing 92 people. We are a wholesale distributor of air conditioning, refrigeration and heating equipment and supplies.

Refrigeration and air conditioning wholesalers and distributors number about 800 companies with approximately 3,500 outlets throughout the United States. The vast majority of these companies are all small and family-owned, started primarily in the thirties, forties and fifties, and are being operated today by the second or third generation.

Our marketplace function is to supply over 50,000 small contractors and service organizations with equipment, parts, and CFC refrigerants, which they in turn use to install and service the refrigeration and cooling equipment in food processing plants, grocery stores, homes, offices, hospitals and so on.

The five domestic producers of CFC's sell directly to us, the wholesalers. We maintain the inventory, provide credit and supply technical assistance to the contractors. The needs of the contractors are, in most cases, immediate. They generally do not know from day to day what equipment, what type of CFC refrigerant or how many pounds they will need for their next job. Our function is to provide for them, on a local level, on an instantaneous basis, the variety and quantity of components and refrigerant they may need.

CFC's have an importance to our business far beyond their immediate sales dollars. CFC's directly account for only 15 to 20 percent of my company's sales, but a decrease in supply would directly affect another 60 percent of our sales—the sales of other components that make the system function.

As small businessmen, my competitors and I are quite concerned over EPA's proposal to limit CFC availability and to auction off or allocate production or use rights. How would we fare bidding against large corporations for this vital product or against each other? Could we obtain what was needed, when it was needed; and, if so, could we afford it? How could we plan and operate efficiently, and how could our customers, the contractors, take on accounts under the tremendous uncertainty over the availability of refrigerant supply?

I don't know, and frankly I am darned worried that such a regulation would place many small businesses in financial jeopardy—businesses such as mine—which have limited resources and are both labor and capital intensive.

In closing, I would like to briefly review several points discussed by my fellow panelists. The alliance strongly supports the position of S. 517 that regulation of CFC's be conditioned either upon evidence of a clear hazard or upon development of an international scientific assessment and, if needed, the establishment of an international control program.

Obviously, if analyses of actual ozone measurements indicate a problem is developing, we must act. But absent such evidence, it seems ridiculous to burden the American people with such a costly and environmentally ineffective regulation. We applaud the direction to EPA by Congress of the provisions of S. 517 and urge that these provisions be enacted.

The alliance appreciates the opportunity to present testimony in support of S. 517. We would also note that the alliance's detailed comments on EPA's proposal are available if the committee desires. And last, we would, of course, be pleased to provide additional information or clarification on any of the topics touched on this afternoon.

We would now be delighted to answer any questions you might have.

Senator GORTON. First, Mr. Lynch, I have in my notebook for this hearing a statement from the Alliance for Responsible CFC Policy. I assume you would like to have that included in the record.

Mr. LYNCH. Yes.

Senator GORTON. It will be included. (See p. 188.)

Mr. Masten, I noted that in your testimony you speak about research which you have funded at universities and independent laboratories. Then you say, and many more millions have been spent on in-house research, including work on the development of alternative fluorocarbons.

Could you briefly outline to the committee what the status of that development is at the present time and what promise it holds for the future?

Mr. MASTEN. Speaking specifically for Du Pont, we have spent about $20 million on trying to develop alternative fluorocarbons. I think first you have to recognize that what we are trying to do is develop an alternative to a product that has established a rather unique position from the safety and toxicology and environmental position.

At this stage, we have been unsuccessful developing alternatives with the guidelines that we use: safety, toxicology, economics, and performance. We do not have in hand a suitable alternative, for example, for refrigeration, as Mr. Norris referred to. We think the prospects of success are rather remote. I don't know of any research at present that would lead us to optimism about developing successful alternatives.

Senator GORTON. In your view, and any of the other panelists may comment on this question if they wish to do so, in your view, the kind of regulatory scheme which is outlined in the EPA paper limiting the availability of fluorocarbons would obviously drive up the price.

Mr. MASTEN. Yes.

Senator GORTON. Some present users would be driven out of the market. Is it your view that that would provide any spur or any incentive toward the development of other alternatives? What would, in fact, at the present time or in the future be the fate of those industrial enterprises which would no longer use CFC's under that kind of situation? Would they go to one of these less environmental methodologies or would they be likely to have been provided a spur to develop something new?

Mr. MASTEN. I think first that you certainly hit upon a very important point. Before we regulate the use of CFC's, which have a proven safety and an environmentally acceptable performance, we ought to make sure that whatever other chemical that we push people toward also is environmentally acceptable.

At this stage of the game, that study has not been carried out. We have great concern about that. Again, Mr. Norris mentioned some of the refrigeration alternatives.

I think that the impact of a production cap or an auctioning of permits on programs would be basically to cut back research and to guarantee there would be no further capital expended in the area of production of CFC's. CFC production plants are very highly capital intensive. In order to build a plant with known technology, it is about a 5-year planning span from start of the plant. A new plant will take 7 to 10 years with today's added emphasis on toxicology. I don't think we would be willing to invest capital, nor do I think that we would compete effectively with other products for capital in an area that had so much uncertainty attached to it.

So my answer really is no, I do not think that would spur development of alternatives. I think it would restrict any further capital investment in the industry.

Senator GORTON. Does any other panelist wish to comment?

Mr. LYNCH. May I comment?

Senator GORTON. Yes.

Mr. LYNCH. I think there is another consequence of a cap program, which is to create a ripple effect that will run through the industry in ways that are not clearly obvious. Many companies, particularly larger ones, who compete at the present time rather ineffectively overseas, have discretionary business segments in which to invest money. If there is the threat of a cap or the existence of a cap, there is enough shortage of investable funds that those companies will be making discretionary decisions in other directions.

I think the evidence is very clear that Japan is putting on a major surge in trying to capture the air-conditioning market in the Third World countries. We meet them there every year. I think the consequence of this will be that a slack will simply be picked up by other countries as the United States is made progressively less competitive because they will simply not be investing in a business where there is the threat of a U.S. cap.

Mr. NORRIS. If I might comment. A cap or any arbitrary restriction by definition creates a shortage. That is why the price goes up. It also will create a need to allocate and decide between essential usages, assuming that there are no substitutes that are attractive.

At some point that becomes a very difficult kind of decision, which left to the free market drives the price up and the consumer price of goods up. If political pressures develop, you could very well be faced with a situation much like we had with gasoline allocations which, frankly, I don't think the record of the Government in allocating our limited gasoline supplies was overwhelmingly good. I am not sure you would want to get into that box again.

But it is very easy to project that kind of a problem with a restricted supply of CFC's with so many essential usages that we are competing with.

Senator GORTON. Thank you. It is necessary for me now to go to the floor of the Senate. Senator Bentsen has kindly agreed to carry on. He may have a significant number of questions. In any event, I will return to hear the last witness.

Senator BENTSEN [presiding]. Thank you very much, Mr. Chairman.

What has been the reaction of the world scientific community to the ozone depletion theory? In turn, what have other countries done? What have the European countries or the Japanese done in the way of additional regulation and curtailment of the output for CFC's? Can one of you speak to that?

Mr. MASTEN. Yes, I will.

Specifically, the countries you mentioned, Senator Bentsen, are the Japanese currently up to this point in time have done nothing. There is no restriction on the use of CFC's as propellants, which we have banned in the United States. In the past 6 to 9 months, the Japanese Government has formed a commission to review the situation to see what they might consider appropriate action. So right now it is in a study phase with respect to propellants. There is no consideration of other uses.

I think probably the most important area of the world to compare ourselves to would be the EEC. We produce about a third of the world's fluorocarbons in the United States. That is down from 50 percent before the aerosol ban. And the EEC produces about 50 percent. We are about the two major producers in the world.

The last meeting of the EEC commission in June 1981 reaffirmed their position that they believe the theory is cause for concern, that there is need to continue work on understanding the theory better, but at this time there is no justification for going any further than they have already gone with respect to any regulation.

The EEC currently has agreed to reduce the use of CFC's as propellants by 30-percent in the period 1976 to 1981. This 30 percent reduction compares to the ban in the United States.

To put it in another perspective on a world basis, in a more general position, over 40 percent of the CFC's produced in the world are used as aerosol propellants today. So we can conclude very quickly that we in the United States have not been successful in causing the rest of the world to follow our lead.

The British Department of Environment produced a report 1½ years ago, just about the time of our 1979 NAS report. In this report they said there is reason for concern, but there is no justification for regulation. So in the world, Norway and Sweden have banned the use of CFC's as propellants. Neither Norway nor Sweden are producing countries. Canada has banned the use of CFC's as propellants in a more limited restriction than we have in the United States. The rest of the world has essentially done nothing.

If I could sort of slip off and make a side point, to put the thing in perspective, we get involved in the science and effects. Basically where we are is, I believe, that we can measure ozone. Statistically we can take the ozone results that are collected around the world and funneled to the Canadian national government and calculate acceptably whether or not there is a sufficient change in ozone to cause a human or environmental risk. We have that capability.

In the meantime, the United States has banned the product and the Europeans, who are the other major producing countries, have only reduced its use 30 percent. So we are far ahead of the rest of the world. Any further action by the United States basically is an economic sanction against the U.S. populace.

Senator **Bentsen**. You were talking about an ozone trend analysis earlier. How good is that in the way of judging the accuracy of the theoretical calculations that we have heard?

Mr. **Masten**. The current theoretical calculation of depletion, and this—I will repeat it; I think it was said earlier: The 1979 NAS report said there would be about a 16.5-percent depletion over a period of about 100 years. The current, up-to-date data using those same calculations—and this is agreed to by the scientific groups throughout the country—indicate that depletion is 5 to 8 percent rather than 16.5 percent.

Senator **Bentsen**. What I am trying to evaluate is your trend analysis. Was it you or Mr. Lynch? One of you spoke to the trend analysis.

Mr. **Masten**. The trend analysis, the current theoretical calculated depletion is so small that the trend analysis today cannot confirm or discredit that theoretical calculation.

Senator **Bentsen**. What we are trying to do is protect the environment, obviously. Do all CFC's have the same theoretical effect on the ozone depletion?

Mr. **Masten**. No. They all have different effects. For example, the fluorocarbons 11 and 12, which are used as refrigerants, as propellants in other countries of the world, have a very high theoretical depletion effect. If you take fluorocarbon 22, its depletion effect is no greater than one-twentieth of that of 11 and 12. So they go all over the place.

Senator **Bentsen**. What is the problem of switching to those that have less potential in the way of depletion?

Mr. **Masten**. Because the fluorocarbon products that are made are not all interchangeable. For example, the products that are used as solvent cleaners, which are the fluorocarbon 113 products, are not suitable as refrigerants. It depends on the application and on the specific fluorocarbon. So there is not a total interchangeability of fluorocarbons.

Senator **Bentsen**. Let me get back to the original point again. We are all trying to protect the environment here. What are the problems, what are the risks involved to the environment—maybe Mr. Norris could answer that—if we switch to alternatives? You touched on that in your testimony.

Mr. **Norris**. There are definitely risks, Senator. One of things I think we should point out is those risks haven't been weighed.

Senator **Bentsen**. Are they or could they be more hazardous than what we have now?

Mr. **Norris**. No question about it. The toxicity of those chemicals that are available to us ranges from 5 to 200 times that which exists with Freon. We would be exposing a great number of people, the 700-some-odd-thousand people who are employed in this industry, and those who are not exposed to these chemicals every day, if we started using them commonly as refrigerants. In our industry alone there would be—there would certainly be some adverse health effects just because while we would be extremely careful, accidents will happen when you raise that risk of exposure.

I would point out, Senator, also that if it limits the amount of air-conditioning—we heard earlier from someone who called it the difference between a catastrophe and a disaster, with a potential for 800 to 1,000 more deaths due to cancer, if the theory is valid and we deplete the ozone level. As a matter of relativity, in 1980, where we had the tremendous heat wave in the eastern part of the United States, we had over 1,200 deaths.

Senator **Bentsen**. We had a month of over 100 degree weather in Dallas alone.

Mr. **Norris**. We had 75 days, sir.

Senator **Bentsen**. I know that in years past southerners had a reputation for not only talking slow but thinking slow. But I think much of that was the heat. I can't help but remember working in a southwest corner office on the second floor with no air conditioning and anyone who wore a coat and a tie was obviously a salesman from out of town. You wore short-sleeved shirts and you tried to work on a contract and do the signatures with the sweat of your arm and try to think. I think that is what has happened in the Sun Belt.

One of you has stated that much of it has come about because of air conditioning making conditions much more livable and productive.

One of the other questions I would like to ask you is if the administration was willing to proceed by regulation to accomplish this, then why is legislation necessary?

Mr. LYNCH. I think that it is quite obvious that we certainly would like to have administrative relief. But I think that it is very clear to all of us that administrative relief is a transitory thing. It is easily given and easily taken away.

What we are looking for is to have legislative change to provide a tightening of the guidelines to EPA. We think that in effect we should require evidence of the need for regulation before we suffer the consequences of the regulation impact.

Mr. NORRIS. I might comment also, Senator, that one of the concerns that has been expressed continually in this country is about our productivity and our willingness to invest in productive capital. To do that kind of investment requires a fairly certain future.

To emphasize what Mr. Lynch said, if we do not have this kind of legislation in place, frankly the future is somewhat uncertain in terms of what the regulatory evironment may do to us. We do not want to duck the seriousness of the problem, but we want it based on an international agreement that the science does in fact tell us that there is a problem—not just that there might be, but there is one.

Mr. LYNCH. I think, if I could add to that, there is reason to believe, based on models that have been run, that we have the opportunity to safely find a way to make that determination. We have heard from the technical people earlier that in the next 5 to 10 years there would be reason to expect some much better understanding of the theory. Models that have been run show that if we do nothing for the next 10 years, as compared to a 50-percent reduction in consumption in this country, this would result in something like an increase or, rather, a depletion of only 0.1 percent in the ultimate maximum level of ozone depletion. So we do have the time to study the problem. The purpose of S. 517 is to provide that kind of rational approach before any heavy-handed regulation would impose unnecessary restriction.

Senator BENTSEN. If we switched the emphasis of research to detection of ozone in the stratosphere, how long do you think it would take us to determine the validity of the ozone depletion theory? Do you have any feel for that?

Mr. MASTEN. I think perhaps some of the earlier testimony treated this. I would think that within 5 years we would have a pretty good handle on the theory. I would think on the outside it would be 10.

It is obviously a very difficult prediction to make on how fast research can go because it depends on budgets and the quality of people available. We believe that NASA is doing a very fine job in research and a very fine job in bringing the world together to try to understand the theory. So I would say 5 to 10 years.

Senator **Bentsen**. I am impressed by what I think is a temperate and a well-reasoned approach to the problem that your panel has brought to it. I appreciate that very much. I think you have made a contribution that will be helpful to us.

We have a matter of some significance that has been on the floor of the Senate now for about a week. I happen to be a member of the Finance Committee. They advised me a moment ago that one of my amendments that may well help save the Nation is about to come up. So if you gentlemen will forgive me, I will go to the floor.

We will stand in recess now until the chairman returns and hears the last witness. Thank you, gentlemen.

[Brief recess.]

Senator **Gorton** [presiding]. Mr. Edwards?

Mr. **Edwards**. Thank you, Mr. Chairman. Please excuse me being late.

Senator **Gorton**. We were late, later than you were. We are delighted that you could wait and testify this late in the evening. We would, of course, ask you also to summarize your testimony to the extent that you can do so. We will assure you we will include your entire testimony in the record. You may proceed.

STATEMENT OF THOMAS E. EDWARDS, CHAIRMAN, THE ROVAC CORP., ROCKLEDGE, FLA.

Mr. **Edwards**. Thank you very much, Mr. chairman.

Ladies and gentlemen, my name is Thomas Edwards. I am chairman of the board of The ROVAC Corp. My topic concerns a new, high-efficiency, economic, non-CFC air-conditioning, heat pump, and refrigeration technology. This technology can eliminate entirely the use of CFC's, save about a third of the energy in so doing, and have only a de minimis impact on the major portion of the $25 billion industry that we are looking at in air-conditioning.

Because of my written presentation, I will ask you to put it in the record and highlight it.

Senator **Gorton**. We will.

Mr. **Edwards**. We are all here today, the few of us who are left—thank you for staying—because there is common knowledge that refrigerants that are used in virtually all air-conditioning systems today do have an adverse effect on the stratospheric ozone. My comments will be limited directly to the basic aspects of the existing air-conditioning industry and an available alternative technology and some of the expected effects of its adoption.

To begin, it is interesting to note that in the United States alone there are some 50 million operating air-conditioned automobiles that contain, say, 150 million pounds of CFC's, or 12 in this case. These vehicles emit some 100 million pounds of CFC's annually and consume about 1.5 billion gallons of fuel at an annual cost of over $2 billion. Half of those bucks go across the pond.

There are also about 50 million CFC-based residential and home air-conditioners in existence today. They consume some $17 billion worth of electrical energy annually and emit hundreds of thousands of pounds of CFC each year.

My point is that there already exists a huge number of these air-conditioning systems, some 50 million. However, about 10 million new ones are put into automobile and home use each year.

Now, there probably isn't much that we can do in true fact with the 50 million that are in existence, but what can we do about the 10 million that are built each year? Certainly we can control CFC emissions through proper application of technology and legislation.

The industry that provides these comfort machines for us that are obviously of great importance consists of a relatively small number of CFC chemical producers and a very small number of CFC compressor manufacturers. However, the preponderance of the industry is made up of assistant people and those who make the companion components to the heart of the system; that is, the compressors. Of course, not only the manufacture but the service aspect of this industry is very important.

What I am disclosing today is the existence of a new technology that is similar to existing air-conditioning technology, except that it uses 35 to 45 percent less energy, operates at one-sixteenth to one-tenth the pressure of conventional systems, and uses a very low vapor pressure, naturally occurring hydrocarbon and refrigerant, which is nonalcohol.

In addition, with no capital production for the heart of this system, something we call the circulator, which is relatively small, the investment required to manufacture these units shows and materials show that the machine can be built in production quantities for costs lower than conventional high pressure fluorocarbon compressors.

Because of the similarity to existing air conditioning systems, and this is really the main point, only the conventional compressor manufacturers and the CFC chemical manufacturers would face problems in changeover. The rest of the industry's preponderance would be virtually unaffected.

To summarize the summary, life as we know it on this planet is possible for one reason: because we have the Earth's protective ozone level. Two, the CFC industry disagrees with the rates of ozone depletion predicted by the National Academy of Sciences and NASA and is lobbying actively to disarm EPA's mandate to protect the environment insofar as CFC's are concerned. Three, there now exists an energy efficient non-CFC air-conditioning and refrigeration technology that is very similar to existing systems. Integration of this new technology into the existing industry would present in fact only relatively minor economic displacement from an overall industry viewpoint. Adopting this new technology would not only further preserve the Earth's ozone layer—somewhat moot—but conserve vast quantities of energy as well.

I have some recommendations. I think that in the present form S. 517 and H.R. 1853 should be defeated or modified. I believe that Senate Resolution 460, which involves the development of a nonhalocarbon, nonfluorocarbon air-conditioning system should be passed.

That completes my statement.

Senator **Gorton**. Obviously, your testimony is most intriguing, even to those who obviously won't be involved in any such business but are concerned with the very real problems raised by all of the testimony which we have heard today.

I would like to ask you the degree to which your technology has been presented to the private sector, either to existing companies or the degree to which you have explored the possibility of simply having your corporation go into the business itself in competition with more standard forms of air-conditioners using CFC's. Where do you stand in turning this from the theory into a practical reality in the marketplace?

Mr. **Edwards**. I believe one of the most important things that we have done very, very recently has been the demonstration of this technology in an actual automobile. We have taken a vehicle to New York City, Manhattan, which in the air-conditioning circle is a very, very difficult place to air-condition a car in the summertime because there is no speed.

We have been very effective in demonstrating to the press and to Wall Street the reality of this theory.

We will have a home air-conditioning unit in operation at the end of next month. However, the water collimator, the device you use to carefully measure the efficiency of the system, results continually show in automotive application, heat pump application, and air-conditioning application that the reality of its high performance is a definite.

Senator **Gorton**. Have you attempted to sell licenses or otherwise interest the five major corporations which are engaged in traditional air-conditioner technology?

Mr. **Edwards**. No, sir. The first technical paper related to this particular technology appeared only last February, in Detroit, the latter part of February. The interest that we have received has been from across the Pacific and the Atlantic. We have found a reluctance on the part of the existing industry to take a close look.

However, I have to temper that by stating that much of what the industry saw several years ago was related to much the same kind of machinery but operating in a less conventional thermodynamic cycle.

What I am saying is that very little has been done to expose this technology to American industry. However, I did try at one time. Meeting with rebuffs earlier, I was a little less interested in talking to our friends here. But the result of talking with a very large manufacturer was at first a great deal of interest on the part of the technical paper, but after the decision was made regarding whether to go further with the development or manufacture of this technology—this happened to be for automotive air-conditioning—the company decided no; even if it did all the things you said it will do in your paper, we probably couldn't sell it to Detroit. Therefore, sorry, there is not much we can do.

Senator **Gorton**. Is it your intention to concentrate primarily in the future on attempting to persuade large corporations to interest themselves in working with your techniques or to attempt to manufacture and market the idea yourself?

Mr. **Edwards**. The plan is to do both. Specifically, we will acquire a small heat pump/air-conditioning-type company and integrate our technology into their product lines. Insofar as automotive is concerned, the bulk of the automotive production probably will take place overseas.

Senator **GORTON**. Is your specific technology something that is a trade secret or is it something about which you would be willing to submit to this committee greater details?

Mr. **EDWARDS**. Of course. In fact, please know that any of the industry representatives who are here are more than welcome to come to our laboratory, investigate the efficiencies for themselves—besides the machine, the noise, all the sorts of things that were problems along the way. And yet it is a patented type of item.

Senator **GORTON**. I was going to ask that.

Mr. **EDWARDS**. I suppose there are some 60 patents related to various aspects of what we are doing. We are reasonable folk, and really we are not on the other side of this coin. We would be willing to license on fair and equitable terms, if that is the real point of the question.

Senator **GORTON**. We would be happy to have any additional information which you would like to submit.

Once again, Dr. Edwards, I would like very much to thank you for being so patient and for sharing with us an idea which, if it does turn out to meet the promises which you hope for it, may greatly help us solve this problem.

Mr. **EDWARDS**. Thank you very much. I appreciate it, Senator.

Senator **GORTON**. The record will be open another 10 days, either for additional written testimony which anyone wishes to submit or for questions to be submitted by other members of the committee.

Thank you all very much, especially those who have been here all afternoon and who have participated and have helped us gain knowledge about a very, very difficult question.

Mr. **EDWARDS**. Excuse me, Mr. Chairman. Would it be possible for the SEA paper mentioned as a reference in my prepared text to be entered in the record

Senator **GORTON**. Yes, it would be. Do you have a copy with you?

Mr. **EDWARDS**. Yes. [See p. 219.]

Senator **GORTON**. Thank you all very much. The hearing is adjourned.

[Whereupon, at 6:18 p.m., the subcommittee was recessed, to reconvene subject to the call of the chair.]

[Statements and other material supplied for the record follow:]

Statement of
Dr. Lawrence R. Greenwood
Director, Environmental Observation Division
Office of Space and Terrestrial Application's

National Aeronautics and Space Administration

Before the

Subcommittee on Toxic Substances
and Environmental Oversight
of the
Committee on Environment and Public Works
United States Senate

Mr. Chairman and Members of the Subcommittee; I am pleased to be here to review NASA's Upper Atmospheric Research Program and to report on our continuing efforts to understand the physics and chemistry of the upper atmosphere and to assess the impact of anthropogenic chemicals on the stratosphere. I am accompanied by Dr. Shelby G. Tilford, Chief of our Atmospheric Processes Branch and Dr. Robert T. Watson, Program Scientist of our Upper Atmospheric Research Program.

Several years ago, at the direction of Congress, NASA implemented a program of research, technology and observations of the Earth's upper atmosphere. Since that time, we have provided Congress with two assessments (January 1978 and January 1980) of the potential threat to stratospheric ozone. These assessments reflect the work of hundreds of atmospheric scientists and were produced after extensive discussion and analysis.

The most recent of these reports was submitted over a year ago (January 1980) and I would like to review and update the findings of that analysis. This update will be based partially on the results of a workshop (jointly sponsored with the World Meteorological Organization) convened in May 1981 to define the current status of stratospheric understanding for the next assessment. The workshop involved approximately 115 scientists from the university community, industry, and government--including experts from Australia, Belgium, Canada, China, France, Germany, Holland, India, Italy, Japan, Switzerland, and the United Kingdom. The report of this meeting is being reviewed and the assessment will be forwarded to the Congress by the first of next year.

Ozone Depletion Assessment

At the present time, we estimate that the continued release of chloroflourocarbons CFC-11 and CFC-12 at their 1977 rates will result in a 5 to 10% reduction in total global ozone at steady state (approximately the year 2030). This predicted impact is lower than our 1979 estimate (15 to 18%) as a result of new information on key rate coefficients involving OH and HO_2. Figure 1 illustrates how ozone depletion predictions have evolved since 1974, based upon our improved understanding of stratospheric chemistry. Other man-made gases (e.g. CFC-113, -22, methylchloroform, carbon tetrachloride, etc.) could further increase the steady state reduction of global ozone by about one third. We also estimate that CFC releases to date may have resulted in as much as a 1 percent reduction in the total column ozone and reduction at 40 km (the most sensitive altitude for ozone destruction by chlorine) of a few percent. Recently we have placed more emphasis on understanding the coupling between the effects of other pollutants (such as N_2O, CO, CO_2 and CH_4) and the CFC's. For instance, the doubling of CO_2 levels (estimated to occur by the year 2030 to 2060) is predicted to decrease the potential CFC impact by as much as one third.

I should hasten to add that these estimates are based on one- dimensional analytical models of atmosphere chemistry. Recent two-dimensional model results seem to be comparable with the one-dimensional predictions. However, there continues to be significant uncertainties in input data and a lack of a total understanding of the chemistry and physics governing some key processes. As a result, some uncertainty remains in the absolute value of predicted perturbations.

Statistical analyses of historical ozone data from ground based observations have been studied as a potential means for establishing upper limits of possible changes. Analyses of possible trends in the total ozone between 1970 and 1979 compared with the period 1960 to 1970 have produced interesting, but not conclusive, results. For instance, some analyses have showed a small increase in ozone (approximately 1% between 1970 and 1979 with a confidence limit of about ± 1.4%). Over this same time period photochemical models estimate less than a 1% decrease in ozone due to CFC-11 and CFC-12. At the same time tropospheric ozone levels have appeared to increase possibly influencing the interpretation of the ground-based observation of total atmospheric ozone. Other atmospheric processes occur and there is uncertainty in the statistical analysis induced by the limited data set (only about twenty years at a limited number of locations with varying accuracy and precision). We do not think it is possible to verify the trend analysis models nor to firmly establish limits on the level of estimated impact based solely on analyses of the limited historical data available. We believe that, to date, this data base has neither validated nor invalidated the photochemical models. The Film Clip illustrates the complex natural variability of total ozone on a daily basis as obtained from three months of NIMBUS-7 satellite data during the period February thru April 1979.

While it remains difficult to validate present photochemical models by comparison with the limited observational data on ozone and other species, we must assure that inputs to the models represent the best possible data. Input data are continuously being improved by laboratory experiments, a priori calculations, field measurements and satellite programs. Recent laboratory data for the OH + HNO_3 and OH + HO_2NO_2 reaction rates have modified our concept of the chemical processes that govern the so called "odd hydrogen radical" budget in the lower stratosphere. Additional laboratory data and the contributions of new field measurement techniques continue to provide an expanded data base to improve and test our photochemical models.

Potential ozone decreases in the stratosphere due to CFCs continue to be of concern because of their long atmospheric lifetimes. While our periodic assessments vary in the absolute value of predicted depletion, the fundamental concept that free chlorine in the stratosphere reduces ozone has not changed. We continue to direct our research at reducing the uncertainty and increasing our confidence that the assessments are based on sound scientific and technical data.

Upper Atmospheric Research Program

In 1976, in response to congressional direction, NASA initiated a major research effort to improve the understanding of the physics and chemistry of the upper atmosphere and to improve the assessment of ozone depletion in coordination with the Federal Aviation Administration (FAA), the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA) and the National Science Foundation (NSF). The Upper Atmospheric Research Program (UARP) provides a comprehensive scientific approach to understanding the stratosphere and in particular understanding the ozone layer and its vulnerability. As I discuss it briefly (Figure 2) you will see how it is focused on reducing the uncertainities encountered in making estimates of pertubations to the upper atmosphere.

Theoretical Studies - In the last few years the use of two, and to a lesser extent three, dimensional models has increased. These models have contributed significantly to our ability to study seasonal and latitudinal depletion of ozone. The development and use of these models represents a significant advance and the models predict constitutent distributions in the lower stratosphere better than the one-dimensional models which were the basis of all early work. A part of our ongoing work is directed at improving chemical and radiative computer codes used in two-dimensional models.

The longer term goal of our theoretical studies is to have fully coupled radiation, chemistry, and dynamic phenomena correctly portrayed in three-dimensional models. Progress has been made, but present codes are still seriously limited in how they treat chemistry and radiative feedback. As the results of the laboratory studies (reaction rates, absorption cross sections, etc.) and the field measurement programs (species distributions, transport, etc.) become available, we expect additional progress.

Laboratory Program - A key to continued improvement in theoretical analysis is an improvement in our information about reaction products, reaction rates, photolytic decomposition modes and rates, spectroscopic line strengths and absorption coefficents for key chemical species. Present one-dimensional models make use of over 150 chemical reactions to describe the chemistry of the upper atmosphere. Of these approximately 150 reactions, many now have been measured as a function of temperature and pressure characteristic of the stratosphere. However, we still have not been able to measure these parameters for some key stratospheric reactions. The lack of this data contributes to part of the uncertainty in stratospheric perturbation calculations. Another contribution to our uncertainty is the lack of knowledge about the identity of the products of certain chemical reactions. The products of reactions and photolytic processes may either terminate a chemical chain or they may continue the catalytic ozone destruction. Characterizations of such products for important reactions are underway in several laboratories.

Light falling on the earth's atmosphere from the sun provides both the energy source for photodissociation and a reference light source from which we can make measurements of atmospheric composition. Understanding the variability and the interaction of solar radiation with stratospheric constituents is important for three major reasons; (1) radiative feedback calculations (2) determination of realistic photodissociation rates, and (3) design and development of advanced remote sensors. Presently researchers are working to define the line strengths and absorption coefficients for such key species such as ClO, $ClNO_3$, H_2O_2 and $HONO_2$ and to measure the spectral distribution of ultraviolet radiation as a function of altitude from balloon platforms.

Field and Satellite Measurements - Actual atmospheric observations provide the key to the validation of our theoretical models and, ultimately, to the improvement of our understanding of the atmosphere. We have developed a vigorous program of field measurements of many of the chemical species using a variety of platforms including ground stations, aircraft, balloons and rockets. We have also demonstrated a capability to measure several of the species globally from satellites. In the longer term these field and satellite programs will overcome our greatest shortcoming--we are presently data limited.

Early in the formulation of the UARP, and with the assistance of the Stratospheric Research Advisory Committee, an overall measurement strategy was developed, i.e., "Measurement Strategies for Stratospheric Research should be planned primarily for their utility in verifying and validating theory. They should be constructed such that search for the unexpected is included." Within the UARP, we have tried to implement this approach. Initially, we developed measurements to test key elements of the photochemical theory. As a first step, techniques for observing the source/sink molecules (i.e., CFCs, N_2O, HCl, HNO_3, etc.) were developed. As these techniques confirmed the presence of these compounds, more extensive experiments utilizing simultaneous observations of several species (including radicals) were made. The results of these observations are now being used to improve and validate our photochemical models. Several of the balloon borne instruments have recently obtained simultaneous measurements of several important species. These include ClO and ozone measured remotely with a microwave limb sounder and in-situ with a resonance fluorescence technique; ozone, water and others measured with an in-situ mass spectrometer; HF, HCl and other halogen species measured with an infrared emission spectrometer; and OH and ozone measured with an ultraviolet LIDAR systems.

We are conducting a series of balloon, rocket and aircraft measurements utilizing a number of different instrumental techniques to measure the same species (i.e. O_3, H_2O, HNO_3, HCl, NO, etc.). These will provide an absolute intercomparison of currently existing measurement techniques.
Taken together, the field measurements have developed a better (though still not complete) picture of the behavior of ozone and other species in the stratosphere. For example, the results of recent total

chlorine measurements seem consistent with the sum of measurements of individual halocarbons. This indicates that there are apparently no large, unaccounted for sources of atmospheric chlorine. A more complete picture will require knowledge of the vertical distribution of many stratospheric species. We have mounted an intensive balloon program to obtain these data.

Satellites provide us our best means, and frequently our only means, for obtaining consistent global observations. The data from NIMBUS-7 and the Stratospheric Aerosol and Gas Experiment (SAGE) have been validated and are now becoming available for detailed analysis. They provide observations of trace species and temperature in the stratosphere which will be extremely useful as input to global models and for testing our theories regarding the coupling between chemistry, dynamics and energetics. For the first time, we now have available daily global maps of total ozone, ozone profiles and stratospheric aerosols; data on the diurnal variability of NO_2; distributions of nitric acid; H_2O; and the first measurements (other than individual rocket or radiosondes) of stratospheric warming events.

Together, NASA and NOAA are preparing to initiate global ozone measurements from the operational meteorological satellites. The Solar Backscatter Ultraviolet instrument flown on NIMBUS-7 to measure ozone profiles is being adapted for flight on the NOAA polar orbiting satellites. The first such instrument is planned to fly in 1984 and a similar instrument will be flown at least through 1987.

Our most critical need, one that is beyond our present approved capabilities, is for global simultaneous measurements of many chemical species, of the transport and dynamics in the stratosphere and of the energetic mechanisms that drive both of these. Toward this end we began planning several years ago for the Upper Atmosphere Research Satellites--a potential mission that will measure and map these species and phenomena for several years rapidly and globally.

In the FY 82 budget the Administration proposed the initiation of development of the instruments to be flown on these satellites in a program called Upper Atmosphere Research Satellite Experiments. We have recently completed a review of the conceptual definition of these instruments, and are convinced that those experiments proposed--or a selected sub-set of them--can provide the required simultaneous measurements. Late this year, we will select the final set of instruments for design and development. We are now beginning the definition of the entire mission including the instruments, spacecraft, ground data handling system, and associated theoretical investigations.

Summary

When the Congress first asked NASA to mount a research effort and provide an assessment of stratospheric ozone, the very notion of ozone depletion due to man made chemicals was controversial. Today there is no longer uncertainty about the possibility of an impact, but considerable uncertainty remains regarding the magnitude of the impacts from several possible perturbing influences. In short, we have narrowed the uncertainty somewhat, and we have focused on the real limitations in our current ability to improve the estimates. Our major limitation today derives from the lack of simultaneous data about species and phenomena. But the prospects for improving the situation through the research program I have described are good, and we at NASA continue our strong commitment to a vigorous research program.

(Figure 1, Ozone Depletion Predictions; CFC-11 and CFC-12/aircraft NO_x)

(Film Clip, February-April 1979 Nimbus-7 total ozone data)

(Figure 2, UARP Programmatic Objectives)

OZONE DEPLETION PREDICTIONS

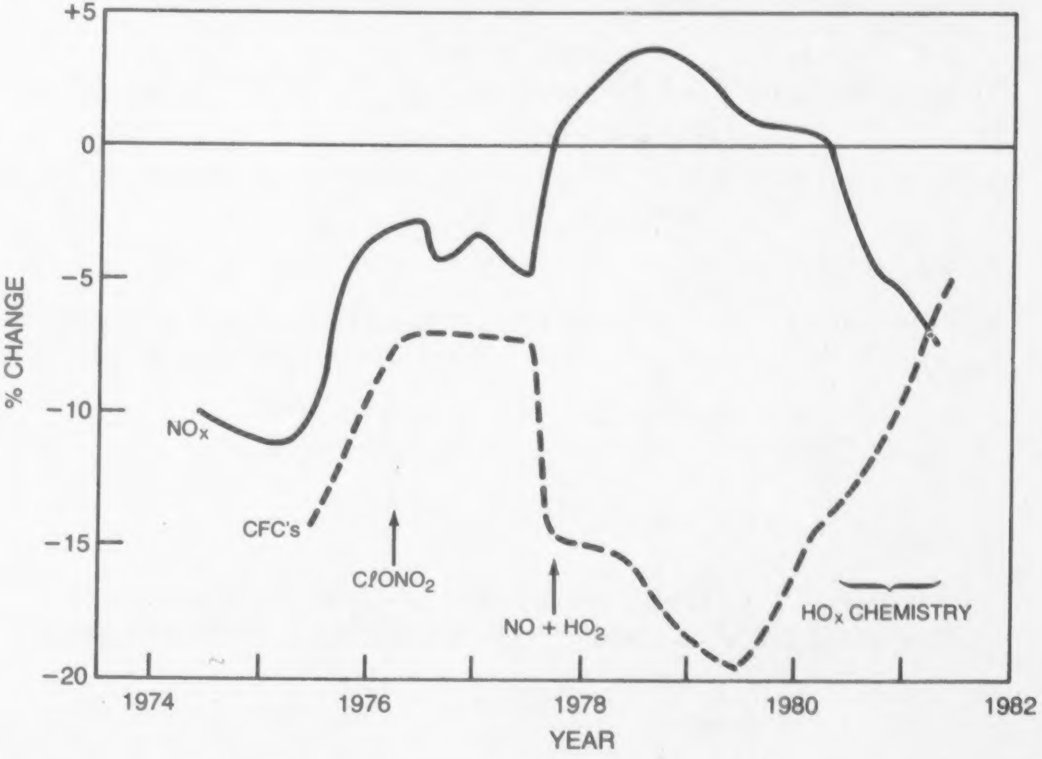

Fig.1

NASA HQ EB81-2593(1)
7/21/81

ATMOSPHERIC CHEMISTRY

GOAL

DETERMINE THE CHEMISTRY AND PHYSICS OF THE ATMOSPHERE AND ITS SUSCEPTIBILITY TO CHANGE

10-YEAR OBJECTIVES

DEVELOP A REALISTIC MODEL FOR ATMOSPHERIC IMPACT ASSESSMENT AND PREDICTION

DETERMINE THE INTERACTION OF RADIATION AND ATMOSPHERIC DYNAMICS WITH CHEMICAL COMPOSITION

GLOBAL CLIMATOLOGY AND MORPHOLOGY OF ATMOSPHERIC CHEMICAL CONSTITUTENTS

DEVELOP SATELLITE AND OTHER TECHNIQUES FOR MEASURING KEY CHEMICAL SPECIES AND WINDS

PROVIDE REQUISITE INFORMATION FOR ENVIRONMENTAL DECISIONS

Fig. 2

NASA HQ EB81-1906
6/4/81

A BRIEF SUMMARY OF THE CURRENT STATE OF SCIENTIFIC KNOWLEDGE CONCERNING CHLOROFLUOROCARBON INDUCED DEPLETION OF STRATOSPHERIC OZONE: WHAT HAVE ATMOSPHERIC MEASUREMENTS TOLD US?

Presented 23 July 1981
to the Senate Subcommittee on Toxic Substances
and Environmental Oversight

By
James G. Anderson
Harvard University

The Rowland-Molina theory, linking the release of fluorocarbons at the earth's surface to the catalytic destruction of ozone in the stratosphere, consists of the following essential elements:

1. Release of the halogen substituted methanes, principally $CFC\ell_3$ and $CF_2C\ell_2$ (hereafter CFC-11 and CFC-12, respectively) into the atmosphere at ground level is followed by the rapid (~ 1 year) distribution of the compounds throughout the troposphere. To a first approximation, there are no physical or chemical removal processes for CFC-11 and 12 at the surface or within the troposphere.
2. The uniform mixing of these compounds throughout the troposphere increases the concentration of chlorine at the tropopause (the upper extremity of the troposphere), and therefore increases the upward flow of chlorine containing compounds entering the stratosphere. Vertical mixing continues in the stratosphere until the molecules reach an altitude where the penetration of solar ultraviolet radiation in the wavelength interval between the major molecular absorption systems of

O_2 and O_3 lead to the photodissociation of both CFC-11 and CFC-12, releasing atomic chlorine.

3. The principal fate of the chlorine atom thus released is reaction with ozone to form the chlorine monoxide free radical, $C\ell O$, which in turn reacts with atomic oxygen to regenerate the chlorine atom. The result is a catalytic chain reaction leaving the chlorine constituents $C\ell$ and $C\ell O$ unaffected, while agumenting the rate of ozone conversion to molecular oxygen. Given that both of the reactions

$$C\ell + O_3 \rightarrow C\ell O + O_2$$

and

$$\begin{array}{l} C\ell O + O \rightarrow C\ell + O_2 \\ \hline O_3 + O \rightarrow O_2 + O_2 \end{array}$$

are sufficiently fast to complete each cycle in the chain reaction within seconds, and that each chlorine atom once delivered to the stratosphere remains there for a period of years, spending a significant fraction of that time in free radical form (i.e., as $C\ell$ or $C\ell O$), it follows that an amount of chlorine orders of magnitude less than that of ozone can potentially alter the rate of ozone destruction in the stratosphere.

We summarize, in the following testimony, the evidence specifically related to the theory of chlorofluorocarbon induced ozone depletion which has been obtained by means of atmospheric observations within the earth's troposphere and stratosphere.

POINT 1: The theory states that to a first approximation no physical or chemical process exists which removes CFC-11 or 12 from the troposphere except upward transport to the stratosphere. Is there any experimental evidence for a process which removes CFC-11 or 12 at the earth's surface or within the troposphere?

An extensive study of the global distribution of the most abundant halocarbons, $CH_3C\ell$, $CF_2C\ell_2$, $CFC\ell_3$, $CC\ell_4$ and $CH_3CC\ell_3$, has been initiated in the past five years by a number of research groups (see, for example, Golden *et al.*, 1980; Rasmussen *et al.*, 1981; Singh *et al.*, 1980; Cicerone, 1981; and Logan *et al.*, 1981). The results of those studies were critically reviewed recently in the World Meterological Office (WMO)/National Aeronautics and Space Administration document, "Stratosphere 1981: Theory and Observation." Observed concentrations of those halocarbons, at the end of 1979, are summarized in Table 1.

Concentration of Major Halocarbons in
Late 1979 given in parts
per trillion by volume

	N.H.	S.H.	Global
$CH_3C\ell$	620 ± 20		620
$CF_2C\ell_2$	315 ± 6	282 ± 6	300
$CFC\ell_3$	184 ± 5	164 ± 5	175
$CC\ell_4$	136 ± 18	125 ± 6	130
$CH_3CC\ell_3$	94 ± 12	125 ± 20	110

Table 1

Measurements of the rate of build up of CF_2Cl_2 and $CFCl_3$ in the troposphere, taken over the past decade, are summarized in the figure below, taken from Logen et al., 1981.

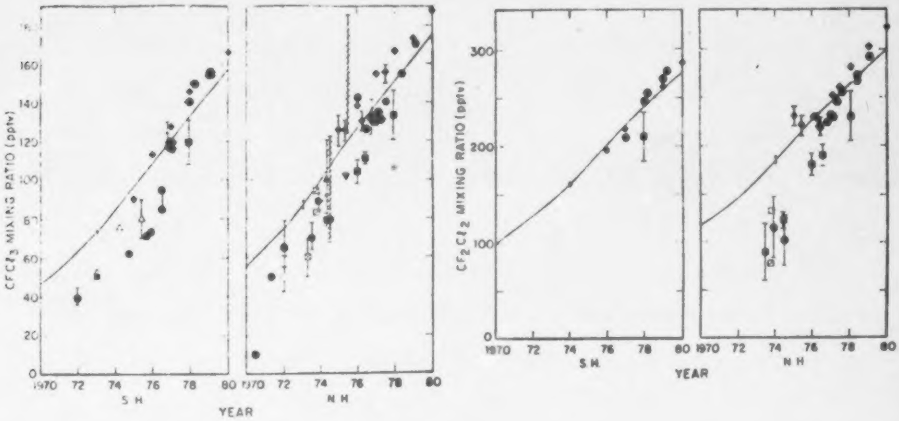

Figure 1. Measurements of $CFCl_3$ and CF_2Cl_2 in the northern and southern hemispheres as a function of time. Each symbol represents data from a different group of investigators; ● (30°-90°), ○ (0-30°), I, Lovelock (1971, 1972, 1974), Lovelock et al. (1973), Pack et al. (1977), NASA (1979); ▲ (30°-90°), △ (0-30°) Wilkness et al. (1973, 1975a, 1975b, 1978); ▨ Zafonte et al. (1975), Hester et al. (1975), ☒ Heidt et al., 1975; ■ Singh et al. (1977a, 1977b, 1979); ◆ Grimsrud and Rasmussen (1975), Robinson et al. (1976), Cronn et al. (1977), Pierotti et al. (1978), Rasmussen et al. (1981); × Fraser and Pearman (1973); + Tyson et al. (1978); ▼ Krey et al. (1977); ○ Goldan et al. (1980). The solid lines show results of the model calculations of Logan et al. (1981) which use release rates for $CFCl_3$ and CF_2Cl_2 given by Bauer (1979). The model assumes that 90% of the release takes place in northern hemisphere. Model results are mean hemispheric values. The arrows (↕) show the range of concentrations from the model for mid-latitudes and the tropics.

The conclusion extracted from these observations is that the average global rate of increase of CFC-11 is 11% per year, and of CFC-12 is 9%

per year. When these data are combined with global release rates for the compounds (see Bauer, 1979), the tropospheric lifetimes for CFC-11 and CFC-12 are comparable to the lifetime one would predict for loss to the stratosphere alone.

Thus, while the question of possible tropospheric removal processes must receive careful and continuous attention, there is currently no identified loss process of quantitative significance for CFC-11 and 12 except upward transport from the troposphere to the stratosphere.

POINT 2: In order for the fluorocarbons to destroy stratospheric ozone, they must penetrate into the stratosphere and photochemically decompose, transforming the chlorine they contain into one or more chemically active forms. What is the experimental evidence for this penetration and decomposition?

As in the case of tropospheric observations, a significant body of high quality data has been collected in the stratosphere at equitorial mid- and high-latitudes in the past five years. A sample of those data, taken from the recent work of Golden et al. (1980) and recently reviewed critically in the WMO/NASA document, "Stratosphere 1981: Theory and Observation," is shown in Figure 2.

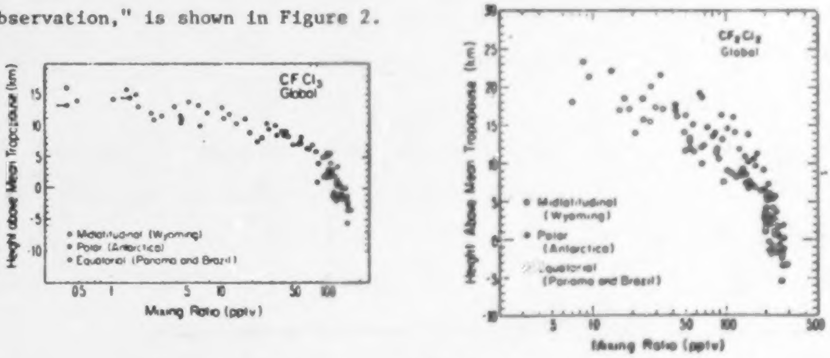

Figure 2. Typical behavior of CFC-11 and 12 as a function of altitude above the tropopause for different latitudes. Taken from Golden et al., 1980.

Based upon the observed penetration of CFC-11 and 12 into the stratosphere at all latitudes and the observed rate of disappearance of these compounds with altitude, decomposition by solar ultraviolet radiation is the principal loss process for CFC-11 and 12 in the stratosphere.

POINT 3: All known sources of chlorine present in the stratosphere are of surface origin. What is the observational evidence relating tropospheric sources with the chlorine budget of chemically active forms in the stratosphere?

Based upon the recent WMO/NASA review of global tropospheric chlorine, in January, 1981 there was a mean of 3.1 parts per billion by volume of Cℓ atoms in the troposphere, and 79% of these were from man made sources. A similar budget analysis for January, 1978 (NASA 1049) shows an average of 2.7 ppb of Cℓ atoms.

Recent measurements by Berg et al. (1980) conducted at 20 km altitude between 16 and 67°N latitude for the period of April to October, 1978 indicate a total chlorine mixing ratio of 2.7 ± 0.9 to 3.2 ± 0.7 ppb. Balloon-borne observations of the chlorine compounds which are currently believed to dominate the total chlorine budget of the upper stratosphere, shown in Figure 3 on the following page (taken from the recent WMO/NASA review), indicate a mean mixing ratio of 2.9 ± 0.6 ppb in the vicinity of 40 km at mid-latitude.

Thus, there are no large differences encountered when the chlorine budget is examined from the point of view of (1) the troposphere inventory of source gases, (2) the total chlorine content of the lower stratosphere, and (3) the chemically active reservoir terms (supplied by the decomposition of the source gases which have diffused upward from the troposphere) in the middle and upper stratosphere. The disappearance of the fluorocarbons

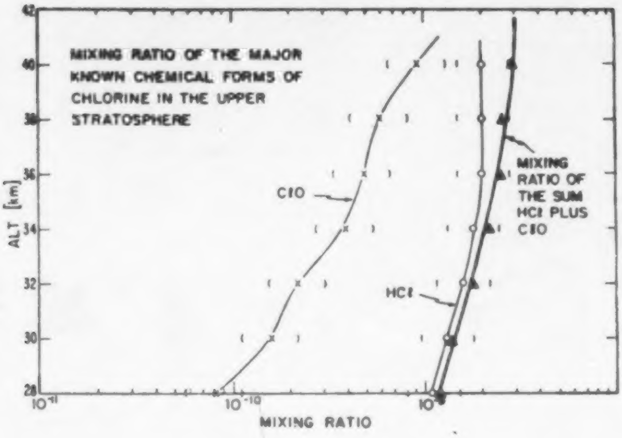

Figure 3. Summary of the mixing ratio of known chlorine compounds in the upper stratosphere.

to a first approximation is matched by the appearance of the chemically active forms of chlorine in the middle and upper stratosphere.

POINT 4: The chlorine constituents which enter as catalytic partners in the major ozone destruction cycle,

$$C\ell + O_3 \rightarrow C\ell O + O_2$$
$$C\ell O + O \rightarrow C\ell + O_2$$

are Cℓ and CℓO. Are these species present in the stratosphere (in the proper altitude interval) in amounts comparable to that required to provide a rate of ozone destruction commensurate with current model predictions?

Two independent techniques, one in situ and one remote, have been successfully used by three independent research groups to detect the existence and absolute concentration of CℓO in the stratosphere. An in situ method has been used to detect the atomic chlorine fragment in the stratosphere. The work has been critically examined in the aforementioned WMO/NASA review.

To summarize, we single out observational evidence on the CℓO radical, for it controls the rate at which the catalytic cycle is completed. Observations of CℓO have defined the mean CℓO concentration to ± 50% as a function of altitude at mid-latitudes. The results demonstrate not only that the catalytic cycle takes place, but also that it occurs with a frequency comparable to that predicted by current computer models.

POINT 5: Have atmospheric observations proven, in a scientific sense, that the release of fluorocarbons at the earth's surface results in the reduction of ozone in the stratosphere?

Isolation of cause and effect in any natural system is notoriously difficult to establish, and serious scientific observations of the photochemical structure of the stratosphere are in their infancy. The library of scientific data on this subject refers, in large measure, to mid-latitude northern hemisphere studies, yet what we confront is a question of global scale. In addition, the atmosphere is by nature a highly variable system which defies simplistic conclusions. On occasion, observations present an unfathomable picture, as in the study of any natural system, which cannot be summarily dismissed, but which must be interpreted with care.

Based upon observational evidence obtained in the last few years, we can answer with significant confidence a limited set of important questions, as reviewed above. What has not been demonstrated is that our description of the chemical structure of the stratosphere is complete, even for the restricted question of chlorine induced ozone depletion, but as any unbiased critic would confirm, important steps have been taken toward defining the probability that chlorine will alter the global distribution of stratospheric ozone. A detailed account of this case appears in the WMO/NASA document, "Stratosphere 1981: Theory and Observation."

It is important to remember that the existence of ozone in the stratosphere relies on a dynamic balance between photochemical processes which both produce and destroy ozone. Considering both the delicacy of this balance (which provides our only protection against solar near ultraviolet radiation) and our routine synthesis and release of chemicals not present during the evolution of the atmosphere, our scientific understanding of the stratosphere is extremely immature. We have but a rudimentary grasp of the relationship between global transport processes, radiation, and photochemistry. Experience with similar chemical systems in the laboratory where we have the luxury of systematically establishing cause and effect through isolation and repetition, has taught us repeatedly that chemical processes are often not what they appear to be, even after careful study.

In summary, what has been demonstrated, through observations of the earth's troposphere and stratosphere, is that (1) a majority of the chlorofluorocarbon 11 and 12 released at the earth's surface enters the stratosphere; (2) a major portion of the chlorine contained in those synthetic molecules enter the "reservoir" of total stratospheric chlorine; (3) the fraction of that total chlorine which exists as $C\ell O$ and thus controls the frequency of the catalytic cycle

$$\begin{array}{l} C\ell + O_3 \rightarrow C\ell O + O_2 \\ C\ell O + O \rightarrow C\ell + O_2 \\ \hline O_3 + O \rightarrow 2O_2 \end{array}$$

in the stratosphere is an observable quantity; and finally (4) the observed concentration of $C\ell O$ (at mid latitudes only), based upon two independent techniques, demonstrates that the loss side of the ozone ledger would be amplified by an amount corresponding to a column depletion of ozone at steady state (in approximately the year 2020, given current release rates) of ~10%, and that this depletion will take place unless a mechanism can be found which balances the loss.

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STATEMENT OF
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PESTICIDES AND TOXIC SUBSTANCES
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
SUBCOMMITTEE ON TOXIC SUBSTANCES AND ENVIRONMENTAL OVERSIGHT
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
UNITED STATES SENATE
JULY 23, 1981

Good morning, Mr. Chairman and members of the Subcommittee. I am Edwin H. Clark, Acting Assistant Administrator for Pesticides and Toxic Substances of the U.S. Environmental Protection Agency. With me is Dr. Herbert Wiser, Director of the Stratospheric Modification Impact Research and Assessment Program in EPA's Office of Research and Development. I am pleased to appear before you to discuss EPA's activities related to chlorofluorocarbons (CFC's).

In my remarks I will briefly review the history of EPA's involvement in the chlorofluorocarbon issue and then describe the scientific evidence we have to date on the environmental and possible health effects of CFC's as well as on EPA's efforts to evaluate the possible economic impacts of various control actions.

Chlorofluorocarbons (CFCs)

Chlorofluorocarbons or CFC's are a family of chemicals that have found extensive use as aerosol propellants, as foam blowing agents, as heat transfer media in air conditioning, refrigeration, and fast food-freezing, as solvents, and as chemical intermediates.

In the mid-1970's, atmospheric modeling studies were conducted indicating that continued world CFC emissions might lead to about a 7 percent future depletion of stratospheric ozone. The range of the estimate was from 2 to 20 percent. Since stratospheric ozone limits the amount of solar ultraviolet (UV) radiation reaching the earth's surface, there was concern that damage to the ozone layer might cause adverse health and environmental effects.

After receiving an assessment of the theory by the National Academy of Sciences in 1976 and regulatory recommendations by the Interagency Task Force on Inadvertent Modification of the Stratosphere (IMOS), and after holding public hearings, the Food and Drug Administration and the Environmental Protection Agency prohibited nonessential aerosol uses of CFC's in the United States. EPA decided to regulate aerosol uses separately from nonaerosol uses because substitutes were readily available for most aerosol applications while alternatives for many nonaerosol uses were difficult to identify.

The 1977 amendments to the Clean Air Act required additional research and assessments of the ozone depletion issue. In response to these requirements, the National Academy of Sciences (NAS) published its second major assessment of the CFC problem in December, 1979. It estimated a 16.5 percent most probable value for steady-state depletion if 1977 emission levels were maintained, though the depletion level could lie between 5 and 28 percent, both extreme values having equal probabilities. Therefore, in 1980, we considered 16.5 percent as the most probable value while maintaining constant awareness of the possibility of other values within the uncertainty region. At the November, 1980 United

Nations Environment Program's Coordinating Committee on the Ozone Layer (UNEP/CCOL) annual meeting, the EPA-led U.S. delegation of scientific experts from NASA, NOAA, DOE and EPA presented new laboratory obtained chemical reaction rate data and analyses which led to an estimated 10 percent ozone depletion value--a lessened effect of CFC's on the stratosphere.

Based on further refinement of the data, present estimates by involved scientists (from throughout the world convened in a NASA/WMO workshop in May 1981) are that continued emissions of CFC's -11 and -12 at the 1977-1979 level may result in a 5 to 8 percent stratospheric ozone depletion.

Existing uncertainties in atmospheric processes are still such that these estimates may be in error by a factor of about two in either direction. Consideration of other halocarbon emissions and their potential impact on stratospheric ozone increases the estimates by about 30 percent.

Two conclusions may be drawn. First, the estimates have oscillated greatly over the years between 1974 and 1981. Overall the estimate of effects have ranged from a high of 20% ozone depletion value to the present low of 5% ozone depletion value. Second, we are still unable to predict with confidence an ozone depletion value, given the complexity of atmospheric reactions and the current sparcity of monitoring data to validate the estimates.

EPA signed a contract on May 1, 1981, with NAS to provide a new assessment by December, 1981, but we will be working with the NAS to provide a longer period of time in order to properly consider the latest technical information. The NASA/WMO workshop report is to be one of the working documents, plus any other reports the NAS deems relevant and important, for the NAS assessment.

Best existing instrumentation and statistical methods limit our ability to reliably determine changes of less than about 2%. It appears, however, that no measurable change to date has been detected. Moreover, we should not expect to detect any changes, for the theory of ozone depletion by CFC's, if correct, estimates less than a 1% decrease in global average stratospheric ozone should have occurred to date.

The Estimated Effects of Ozone Depletion

Ozone filters out most of the incident biologically damaging solar UV-B radiation. The role of UV-B radiation in causing some forms of nonmelanoma skin cancer (rarely fatal) is well known through animal laboratory and epidemiological studies conducted throughout the world, but the correlation between UV-B exposure and an increase in nonmelanoma skin cancer as a function of stratospheric ozone decrease can only be estimated, based on numerous assumptions. In the U.S. there are approximately 300,000 cases/year of nonmelanoma skin cancer.

Adequate definitive knowledge does not exist that identifies UV-B radiation as a causative agent for melanoma, the frequently fatal form of skin cancer, though it may be one of the causative factors. There are about 6,000 fatalities per year from melanoma in the U.S. Animal studies are not possible because the human being is the only animal that gets melanoma.

Limited and imprecise data exist on the biological effects of UV-B radiation increases on terrestrial and aquatic plants, fish, and other biota, especially in the natural environment where organisms may have the capability to adapt to small increases in UV-B radiation. Studies on selected key crops in the field (as distinguised from laboratory studies) and on fish are under way to better determine the effects of increased UV-B radiation on food productivity, growth, and diversity, for which effects have been observed in the laboratory.

Present scientific knowledge is insufficiently sensitive to enable accurate quantitative prediction of the effects of UV-B radiation that may be associated with any given ozone depletion level. The ranges of uncertainties in knowledge of effects are too large for precise correlation with ozone depletion estimates.

CFC Production and Use

Total CFC production and use has changed dramatically in the last decade. In the United States, a sharp drop in CFC production followed a peak of over 1 billion pounds in 1974. Use has leveled off recently to about 835 million pounds in 1980. This general decline is the result of a large decrease in aerosol use of CFCs, which dropped from about 500 million pounds in 1974 to less than 25 million pounds in each of the last two years. This was accompanied by a significant increase in nonaerosol CFC use during the same period. Nonaerosol uses grew about 9% annually from 1975 to 1979 and then fell slightly in the recent recession. Recovery of the construction and automobile industries combined with expected market growth in the use of CFC's for solvents, food freezing, and other applications may lead to an eventual increase in production over the 1974 peak.

International Activities Relating to CFC's

Several CFC-producing and CFC-using nations have taken actions to reduce CFC emissions. Canada, Sweden, and Norway have banned most aerosol propellant uses of CFC's-11 and -12, and are considering further actions. A number of other countries have achieved significant reductions in aerosol uses without regulation. Japan has informally capped CFC-11 and -12 production capacity. The ten member nations of the European Economic Community (EEC) are required to ensure that production capacity for CFC's-11 and -12 does not increase and to reduce aerosol propellant uses of these CFC's by at least 30 percent of 1976 levels by December 31, 1981. Several member countries expect to to achieve significantly greater reductions in aerosol propellant uses. The EEC is considering further actions in the areas of foam blowing, solvents, and refrigeration.

The Organization for Economic Cooperation and Development (OECD), has been a forum for exchanging information on science, technology, economics and regulatory aspects of CFC's. The OECD is currently preparing a comprehensive report on CFC's.

The United Nations Environment Program (UNEP) has played an important role in international scientific cooperation on CFC's through its Coordinating Committee on the Ozone Layer. This committee meets once a year to discuss and report on scientific information on the ozone depletion hypothesis, to facilitate the exchange of research information, and to make suggestions for future research.

In April of 1980, the UNEP Governing Council recommended that member governments achieve significant reductions in uses of CFC's -11 and -12, not increase production capacity, pursue further research, and reexamine control measures already taken in light of available data. In May 1981, the Governing Council initiated work on a global framework convention for the protection of stratospheric ozone.

EPA has been involved in international cooperation on scientific research and monitoring, such as the work of the UNEP Coordinating Committee on the Ozone Layer, the World Meteorological Organization, various international scientific associations, and our bilateral research projects with the Netherlands and Federal Republic of Germany on effects of UV-B radiation. In view of the international implications of the CFC issues, it is important that we consider our CFC efforts in the context of the work of the international scientific community.

Recent EPA Activities Relating to CFCs

In October of 1980, EPA issued an Advance Notice of Proposed Rulemaking (ANPR) to gather information about the validity of the ozone depletion theory, the appropriateness of restricting CFC uses, and possible courses of action for the Agency. It is important to emphasize what an ANPR is and what it is not. First: it is not a rule. It is not even a statement that EPA will regulate CFC's now or in the future. Rather, it is an information gathering tool which in this case notified the public that EPA is concerned about the projected growth of CFC's and possible resultant effects on human health and the environment. It informs the public that EPA is considering the question of whether it should issue a proposal to regulate nonaerosol CFC's. It solicits comments and information on a range of issues that EPA must examine before deciding whether to regulate and the best approach if regulation is necessary. Before any final rules could be promulgated, EPA would have to issue a proposal, including supporting analyses, and provide an opportunity for public comment. As you know, the final rule would have to be based on the record in the proceedings.

EPA received over 2,000 comments on the Notice. It is clear that many segments of industry consider the strategies discussed in the ANPR to be controversial. The Agency's technical staff believes that many of the issues raised in these comments deserve further analysis. EPA is evaluating these issues through its staff and contractors. The quality of the comments indicates that the ANPR has succeeded in promoting informed public participation in the evaluation of the issues and development of appropriate governmental and industry actions.

Through EPA's coordination with the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the Department of Transportation and other involved agencies, academia, and industry researchers, we are keeping abreast of new developments in scientific research. Furthermore, given the global nature of the problem, we will continue to monitor the actions of and exchange information with other nations that are major producers of CFCs.

The Agency has not yet decided whether to pursue a proposal or what the nature of a proposal might be. A decision on EPA's future approach on CFC's will be made after the Administrator and other new senior officials have had an opportunity to study the issues, the scientific findings, the available alternatives, and the potential for cooperative action with other nations.

This concludes my prepared statement. I would be happy to respond to your questions.

Testimony of Richard B. Setlow

Biological impacts of a reduction in stratospheric ozone

Richard B. Setlow*

I. INTRODUCTION

Ultraviolet radiation (UV) is harmful to plants, animals and humans and the harmful effects of short wavelengths of UV (so called UV-B) are greater than those of long wavelengths of UV (so called UV-A). UV not only affects the metabolism of cells, but kills and mutates them and is carcinogenic for animals. The great majority of UV-B does not reach the surface of the earth but is absorbed by stratospheric ozone. If the level of ozone decreases, the amount of UV-B striking the earth's surface will increase and one would predict that the harmful effects would increase.

The scientific question that faces the National Academy of Sciences Committee on the Biological Effects of Increased Solar Ultraviolet Radiation are the quantitative biological changes expected from a change in solar UV. As you have heard, we shall approach this problem by convening three workshops--workshops on Molecular and Cellular Effects, Ecosystem Effects and Human Health Effects. The expert participants in the workshops will update and amplify the information in the 1979 National Academy of Sciences Report "Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons".

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*I am a Senior Biophysicist and Chairman of Biology Department of the Brookhaven National Laboratory, Upton, New York 11973. The laboratory is operated by the Associated Universities, Inc. for the U.S. Department of Energy. I have knowledge of the subject under discussion because: 1) my research for the past 30 years has dealt with the effects of ultraviolet radiation on molecules, cells, and animals; 2) I was Chairman of the National Academy of Sciences Climatic Impact Committee Panel on Biological and Medical Effects of Supersonic Flight; and 3) I am the present Chairman of the National Academy of Sciences Committee on the Biological Effects of Increased Solar Ultraviolet Radiation.

From the strictly scientific point of view, our approach will be to address four questions felt by photobiologists to be key ones. 1) What is the relationship betweeen dose and response for single wavelengths in the UV-B region? 2) Do low intensities for long times give the same result as high intensities for a short time? If not, what is the relationship between these variables? How do intermittent exposures, such as exist in the real world, affect the dose response relation? 3) What is the relative efficiency of different isolated wavelengths in producing observed biological effects? A knowledge of this so called action spectrum is the key to making predictions. I shall return to this point in a moment. 4) Is the sum of the effects of isolated wavelengths additive, antagonistic or synergistic? Are there other synergistic agents in the environment, such as chemicals, temperature and visible light?

For simple biological systems, such as single cells and small plants and animals, it is possible to answer such questions by appropriate laboratory experiments, although as of now not all the appropriate experiments have been done. However, the approach to estimating human health effects can not take the direct experimental approach, but must utilize epidemiological information and basic knowledge on the responses of cells to UV and the abilities of cells to repair radiation damage to their genetic material, DNA.

The shapes of the dose response curves determine the effect of small changes in ozone depletion on the biological endpoint. Figure 1 (p. 4) shows three examples. If the dose response curve were a straight line, a 10% change in dose would give a 10% change in effect. If it were curved sharply upwards as in the lower curve, a 10% increase would give rise to a 70% increase in a biological effect. Hence, there is great experimental emphasis on the determination not only of the effective wavelengths of light but of the shapes of dose response curves. We know the effective shapes of such curves for some of the effects of UV-B on plants and animals and we have a good idea as to the shape for non-melanoma skin cancer.

II. BIOLOGICAL SENSITIVITY AS A FUNCTION OF WAVELENGTH--THE ACTION SPECTRUM

Figure 2 (p. 5) shows the changes in sunlight intensity at the earth's surface for different stratospheric ozone concentrations (the 3.4 mm of ozone is a typical one at the present time) and superimposed on these curves is a typical biological sensitivity curve. At long wavelengths there is very little biological effect because the biological sensitivity is low and at the shorter wavelengths, with our usual stratospheric ozone, the biological effect is very low because very little light penetrates through to the earth's surface. The biological effect resulting from a change in ozone depends critically on the shape and the location of the biological sensitivity curve. If this curve is not known from direct experiment or cogent theory, there is no theoretical basis for making a prediction. The curve shown in Figure 2 is typical of those representing effects on DNA and has been found to hold for the killing of mammalian cells, mutation of mammalian cells, and transformation of mammalian

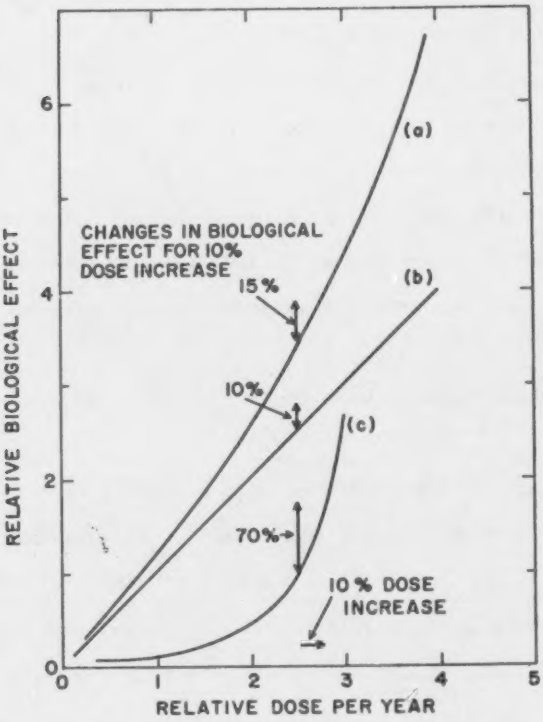

Figure 1: Hypothetical dose response curves to illustrate the effect on the changes in the anticipated biological effect resulting from a 10% dose increase. In the UV-B spectral region, a 5% change in ozone will produce an approximate 10% change in dose.

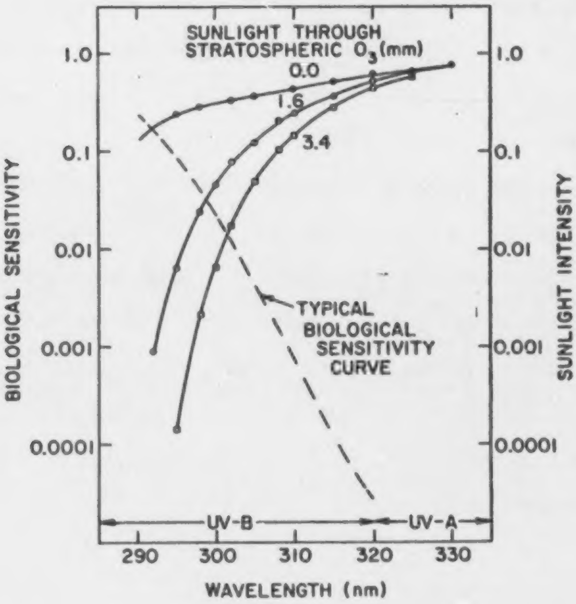

Figure 2: A comparison of the sunlight intensity striking the ground for different levels of stratospheric ozone (the normal amount is close to 3.4 mm). The shape of a typical biological sensitivity curve is also indicated. The curve approximates that for affecting the genetic material, DNA.

cells. Transformation is felt by many to be the equivalent of the initiating effects in carcinogenesis. The biological sensitivity curve in Figure 2 is also consistent with the effects of UV on anchovy larvae. Such a sensitivity curve seems to hold at least approximately for many of the effects on plants and animals and for non-melanoma skin cancer. Unfortunately there are no direct data that delineate the shape of the sensitivity curve for malignant melanoma, in part because there is no good animal model of light induced melanoma.

The application of these ideas to larval fish populations indicates that some of them may be under stress from UV today but because of the many other stresses to which such populations are subjected, predicted levels of ozone diminution will probably not have a major effect on such populations. There are big unknowns in such an assertion and the biggest are the lack of definition of the characteristics of the habitat of such populations and the effect of a small increase in mortality rate from UV on the high natural mortality rate.

III. NON-MELANOMA SKIN CANCER

Non-melanoma skin cancer is the most common of all cancers in the United States. It has an incidence of over 400,000/yr but, because of its low mortality, it is not a serious disease for the great majority of individuals. Nevertheless it does worry people and it incurs health costs because of the need for continued check-ups. This type of skin cancer appears primarily on high-light exposed areas of skin, increases dramatically with age, and increase markedly as one goes further south. There is a wealth of experimental data indicating that the wavelengths responsible for such cancer are in the UV-B region and that a biological sensitivity curve similar to that for DNA is an appropriate one to use. Nevertheless there are many variables who's impact on skin cancer incidence we know little about. Some of these are given in Table 1.

TABLE 1. Some Latitude-Dependent Variables in Non Melanoma Skin Cancer

UV irradiance averaged over the year		
Time of day at which exposure begins	life style	assume these cancel out
Time duration per exposure		
Maximum irradiance per year		
Number of exposures per year		
Age	sampling factors	
Genetic Background		
Occupation		
Other environmental factors (wind, visible light, temperature ...)		

The type of analysis used assumes that the big difference from place to place in the United States is the UV irradiance level. Hence an increase in UV as a result of ozone depletion can be modeled by assuming a change in location. Because we have little information on all the other variables in Table 1 except the first, they are assumed at present to cancel out. There is still an uncertainty in the annual UV dose. One shown in Figure 3 (p. 9) was obtained by a meter and the second, shown on the upper scale, estimated as the annual dose delivered to the DNA of skin cells. Most of the estimates of the effects of ozone depletion on non-melanoma skin cancer, indicate that a 10% ozone depletion would give rise to an approximate 40% increase in non-melanoma skin cancer, with some estimates being as low as 20% and others as high as 80%.

Since non-melanoma skin cancer is primarily a disease of old age and seems in some respects to represent the accumulation of large amounts of UV damage, any change in the intensity of UV-B surface of the earth will not be reflected in an increase in skin cancer until times of perhaps 30 years. For non-melanoma skin cancer the average cost per affected person is low but the number of affected individuals is high making, the total cost high.

IV. MALIGNANT MELANOMA

The 1979 National Academy of Sciences Report indicated that the five year survival rate for this disease was between 65-70% and that the number of new cases in the United States were close to 14,000/yr with a death rate close to 4,500/yr. Melanoma makes up approximately 2% of all cases of cancer diagnosed and approximately 1% of all cancer deaths. Thus it is relatively a rare disease but its incidence has been increasing in the

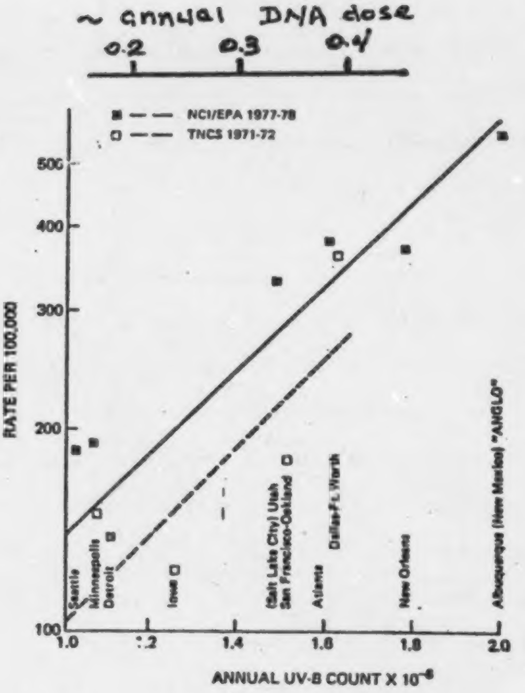

Figure 3: Nonmelanoma skin cancer incidence in the United States as a function of UV-B exposure. The data are from Scotto and Fears, National Cancer Institute, preliminary data as quoted in the National Academy Report (1979) "Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons". The upper dose scale represents that to DNA and is included to illustrate the fact that the available meters giving the annual UV-B count do not satisfactorily give the DNA dose.

United States at the rate of several percent per yr and in Norway at about 7% per yr for the last 20 years. Because melanoma does not appear on the areas of the skin that are exposed to the highest light intensities, nor is it a disease associated with outside occupational exposure as is non-melanoma skin cancer, and the latitude gradient is not as steep as it is for non-melanoma skin cancer shown in Figure 3, there is serious uncertainty as to the role of sunlight exposure in melanoma incidence. On the other hand, the following data indicate that sunlight and UV-B are important in melanoma incidence. 1) Melanoma is primarily confined to light exposed areas (considering the scanty bathing suits now in general use). 2) Melanoma's increase with time is not mimicked by ocular melanoma (a melanoma in tissue which though exposed to light is shielded from UV-B by the absorption by the intraocular fluid). 3) Melanoma appears with an extraordinarily high prevelance in individuals who are defective in repairing UV damage to their DNA--individuals with the disease called xeroderma pigmentosum. Hence the overall evidence is ambiguous but indicates that more than just the cumulative exposure to UV-B is involved in melanoma. Some investigators believe that UV-B is the etiologic agent, others do not. I hope that the forthcoming workshop will permit a consensus opinion to be reached. Although the connection between UV-B and melanoma is weak compared to the association between UV-B exposure and non-melanoma skin cancer, a reasonable and prudent view would be to assume that one of the factors in melanoma incidence is UV-B exposure. If one adopts such a prudent point of view and uses the epidemiological data to estimate the increase in melanoma incidence from a 10% ozone reduction one obtains increases of between 30 and 60%.

V. CONCLUSION

Both experiment and theory associate non-melanoma skin cancer closely with exposure to UV-B. The disease affects large numbers of people but is readily cured. The causal connection between UV-B and melanoma is not strong but on the other hand it is not weak. Melanoma is a serious disease and affects relatively small numbers (14,000/yr) of people. A 10% ozone decrease is estimated to give a 40% increase in non-melanoma cancer incidence (a good estimate) and a 30% increase in melanoma incidence (an uncertain estimate).

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V International Congress on Photobiology, 1968
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NAS-NRC Committee:
Photobiology, Chairman, 1965-1970
Phototherapy in the Newborn, 1972-1975
Climatic Impact of SST, 1972-1975
Panel to Review Statistics on Skin Cancer, 1974-
Space Science Board, 1975-1978
Solar Power Satellite Systems, 1979-1981
Federal Research on Biological and Health Effects of Ionizing Radiation, 1980-1981
Biological Effects of Increased Solar Ultraviolet Radiation, Chairman, 1981-
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Chairman, 1972

Biology Department
Brookhaven National Laboratory, 1971-1973

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Carcinogenesis (Franklin Institute), 1978-

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Finsen Medal for outstanding fundamental contribution to Photobiology and Repair of Nucleic Acids, at 8th International Congress on Photobiology, Strasbourg, France, July 20-25, 1980.

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Introduction

Humans, like most life forms, live in a complicated, dependent relationship to the sun. All life derives its energy from the sun; photosynthesis drives all food chains and the sun is the major source of heat. In vivo ultraviolet photochemistry in the skin is an obligate step in vitamin D synthesis, and visible light photochemistry within the retina allows vision. On the other hand, the ultraviolet component of sun harms or kills cells including those of intact living humans. During evolution, skin developed optical and chemical protection against ultraviolet radiation and limited physiologic mechanisms for increasing that protection.

The existence of the ozone layer provides protection from ultraviolet radiation (UVR) by absorbing the most harmful wavelengths. The shortest wavelength region of UVR is entirely omitted from the earth's surface and the biologically active, so called UV-B, range is reduced by the ozone layer. Most complex life forms have developed further means of reducing the UVR exposure dose. These include UVR absorbing pigments, light avoidance responses, intelligence and other properties.

Direct Human Biologic Effects of Increasing Ultraviolet Radiation

Reduction in stratospheric ozone will result in increased biologic hazards of uncertain magnitude. The direct effects on humans include increases in the known UVR induced effects of human skin, eye, and immune system. In the skin UVR causes sunburn which is one component of an inflammatory and repairative response to UVR cell injury in skin. Solar degeneration is a cumulative alteration of the skin caused by chronic sun exposure. It also is called "premature aging" because the net result (wrinkling, irregular thickening and thinning, irregular increases and decreases in pigmentation) is often interpreted as similar to old skin. UVR also causes skin cancer; the epidemiologic evidence in man and experimental evidence in animals is convincing. Most skin cancers are easily treatable but there is a definite morbidity, cost, inconvenience, cosmetic liability and mortality associated with skin cancers. The association between melanoma, a less common and potentially fatal form of skin cancer, and sun exposure is complex and uncertain.

The eye can also be damaged by UVR. Cell injury in the cornea and conjunctiva cause a painful reaction (keratoconjunctivitis) which lasts several to many hours and usually subsides without sequelae. Anatomic considerations and physiologic bright light avoidance responses usually protect the eye from short term overdose to the ultraviolet component of the sun. However, there is some evidence that certain forms of cataract may be related to cumulative changes in the lens which result from chronic exposure to solar UVR.

Recently it has been discovered that UVR can alter the immune system of animals and humans. The immune system is a complex and diverse collection of circulating and non-circulating cells throughout the body which determine protection against certain diseases and infections. A mild sunburn results in decreased viability and function of lymphocytes (circulating white blood cells) for up to 24 hours. Certain allergic reactions, skin graft rejection, and other immune functions can be altered by tolerable doses of UVR to intact skin. Much of the UVR which strikes skin enters into the body to the level of the superficial blood vessels. The skin is, in fact, overperfused. The blood flow to the skin is 30 or 40 times greater than is necessary to supply nutrients and metabolic needs of skin cells. This is because blood flow in the skin is primarily designed for heat regulation of the host as a whole. The entire blood volume may pass through the skin in a few minutes. This blood is available for radiation by ultraviolet and visible radiation.

All Ultraviolet Radiation is Not the Same

Certain ultraviolet wavelengths are more effective or efficient at causing cell injuries than others. This is because certain important molecules in cells absorb certain specific wavelengths and this absorption changes the molecules so that they may participate in chemical reactions. Electromagnetic radiation comprises a continuous spectrum of wavelengths varying from fractions of Angstroms (one Angstrom, Å, equals 10^{-10} meters) to millions of meters. Based on phenomenological criteria, these wavelengths have been classified into spectral regions (Figure 1). The portion of the spectrum causing direct changes in humans (200-800 nm) is capable of penetrating into skin and is capable of causing chemical changes when absorbed by molecules. Within this range, a useful wavelength unit is the nanometer (nm). One nm = 10^{-9} meters (m) = 10 Angstroms (Å) = 1 millimicron (mμ). Visible light (wavelengths of approximately 400-700 nm) pass through the human lens and are absorbed by retinal chromophores to initiate the chemical changes which result in vision, an instantaneous map of our environment. This radiation also penetrates through skin and subcutaneous tissues, but under usual circumstances does not cause photochemical events that result in recognizable tissue alteration or damage. The ultraviolet radiation region of the spectrum is further subdivided into several bands in terms of phenomenologic effects. The subdivisions are largely examples of the arbitrary and egotistical nature of man because they are largely based on how radiation affects humans or is understood by them. Photobiologists generally divide the ultraviolet spectrum into three portions, called UVA, UVB, and UVC, in order of decreasing wavelength (Figure 2). Diagrammatically these spectral regions can be considered to be defined by plotting the effectiveness of UVR at causing sunburn (called the erythema action spectrum) and the spectrum of sunlight as it reaches the earth's surface after being filtered by ozone (called the terrestial solar spectrum).

The wavelength range from 200-290 nm is called UVC. Radiation of wavelengths shorter than 200 nm is mostly absorbed by air, and significant solar radiation of wavelengths shorter than 290 nm does not reach the earth's surface because of absorption by ozone formed in the stratosphere. Radiation in the UVC band causes erythema of normal skin and photokeratitis of the eye very efficiently. UVC is also called "germicidal" radiation because of its effectiveness in killing one-celled organisms, "shortwave" UV because the wavelengths in this region are the shortest ultraviolet radiation transmitted through air, and "far" UV because this ultraviolet region is the furthest from the visible spectrum.

Solar ultraviolet radiation of wavelengths between 290 and 320 nm (UVB) reaches earth in relatively small quantities but is very efficient in causing sunburn of human skin. For this reason, it is often referred to as the sunburn spectrum of the "erythemal" band. Because of its relative spectral position, UVB has also been referred to as mid UV, or middlewave UV. Epidemiologic evidence suggests strongly that solar UVB causes skin cancer in man. Ultraviolet radiation of wavelengths longer than 320 nm

(UVA, 320-400 nm) is both melanogenic and erythemogenic but the amount of energy required to produce an effect is orders of magnitude higher than for the UVB region. UVA is sometimes referred to as longwave UV and is also called near UV because of its proximity to the visible spectrum. This spectral region has also been called "blacklight" because its principal use for many years was to excite fluorescent and phosphorescent substances that reradiate the absorbed energy as visible light.

A decrease in "ozone layer" will not only permit more UVR to reach the earth but it will also shift the terrestial solar spectrum curve to the left (see Figure 2). This permits more of the effective radiation to be present. Even if the absolute increase in the amount of UVR is small, the shift in the spectrum means that much of that UVR which is increased is very biologically effective. For example, simply doubling the amount of solar UVR would cause sunburn to occur in half the time previously required. But shifting the terrestial solar spectrum to the left would further decrease the time required to sunburn because the UVR would then be more efficient at causing sunburn.

Protection Against Ultraviolet Radiation

All skin is not the same. All skin is not equally susceptible to UVR damage. There are two principle physiologic barriers to UVR. One is a layer of dead cells, protein and other biomolecules on the outermost surface of the skin which absorbs the most biologically active wavelengths of UVR. This layer, called stratum corneum, is increased as a repairative response to UVR injury of skin and is approximately the same in all individuals. The other physiologic, chemical and optical protecter against UVR is a pigment called melanin which is produced by cells in the outer layer (epidermis) of skin. This pigment gives skin its brownish color. The production of this pigment is increased after sun exposure (tanning). The baseline amount of melanin and the capacity to increase melanin production are genetically determined. White persons have much less melanin than blacks. Among caucasians there is a wide range of melanin content. In general, those with the least baseline pigment have the least capacity to tan. It is these individuals who are most susceptible to sun damage of all kinds.

Two additional excellent barriers against UVR are available to modern humans. There are now excellent sunscreens, chemicals which when applied to the skin absorb UVR before it reaches viable cells. Meaningful sun protection factors range up to greater than 10. This means that if it normally required 25 minutes of sun exposure at noon in June to cause minimal sunburn in a fair person, with the use of a sunscreen with a protection factor of 10, it would require 250 minutes to acquire the same amount of sunburn. This amount of protection is quite large compared to the small increases in UVR estimated to result from ozone depletion. The other and most effective barrier is the human brain. Humans have the intellect to avoid sun and protect themselves from acute and chronic sun damage. Modest changes in behavior can decrease solar UVR by factors much larger than the least conservative estimates for ozone related increases in UVR. Avoiding sunburn is no assurance that cell injury is avoided. UVR has been shown to cause DNA damage, cell death, pigmentation and cumulative alterations of skin at subsunburn exposure doses.

The relationship of UVR exposure dose and skin cancer is complex and involves such variables as dose rate, intermittent versus constant exposure, waveband interactions, and other factors. Certain environmental, industrial, medicinal, or botanical chemicals can augment, decrease, inhibit or promote the carcinogenic properties of UVR. Solar degeneration is even less well understood. There are uncertainties about the exact spectrum causing these changes.

Summary, Conclusions, Suggested Perspective

1. If UVR increases and there is a shift in terrestial UVR to include shorter wavelengths there will be an increase in direct effects of solar UVR on human skin, eyes and immune system. This increased hazard is real, of greater threat to white persons than black persons, is difficult to quantify, and is probably quite small compared to the capacity of humans to compensate by increasing their use of sunscreens or intelligence to diminish UVR exposure. The willingness of humans to use protection is another matter.

2. The direct hazard to human tissue may be less important than the hazard to the ecosystem. This hazard is also real and much more difficult to quantify. It is at this stage largely unknown, and we may never be able to gather all the information necessary to entirely predict all of the effects of decreasing the ozone layer. The cumulative alterations to our ecology may exceed nature's ability to compensate without major effects on humans. The present terrestial solar spectrum was determined over millions of years and allowed expansive evolution for hundreds of millions of years. We may be very bold to significantly alter that spectrum in a few hundred years. We may be in for some ecological surprises. An algae, a plant, a marine form, an interdependent delicate balance somewhere in an ecological niche may break or overwhelm some life chain leading directly or indirectly to very noticeable components of our biosphere. In my opinion, this type of

threat exceeds the direct increased hazards to the skin, eye and blood.

3. I have insufficient expertise in regulation affairs to recommend a course of action. However, I believe that ozone depletion by manmade mechanisms may present us with another important test case. Are we able to elect not to use the most convenient and modern technology and the most economically competitive methodology in order to preserve our ecology. Eventually we must begin to make some decisions which yield more to ecological concerns. The ozone concerns may not be the most important single critical question but the use of good judgement in questions of ecology-technology balance, along with certain related defense stances, will determine our future existence.

Figure 1

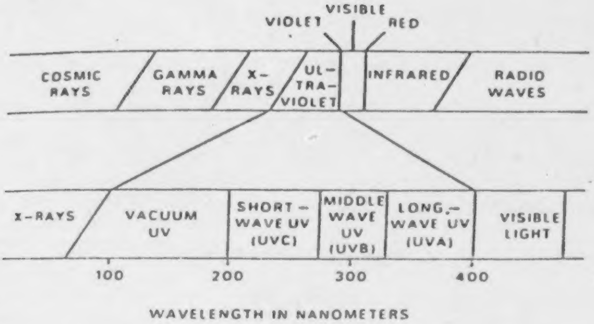
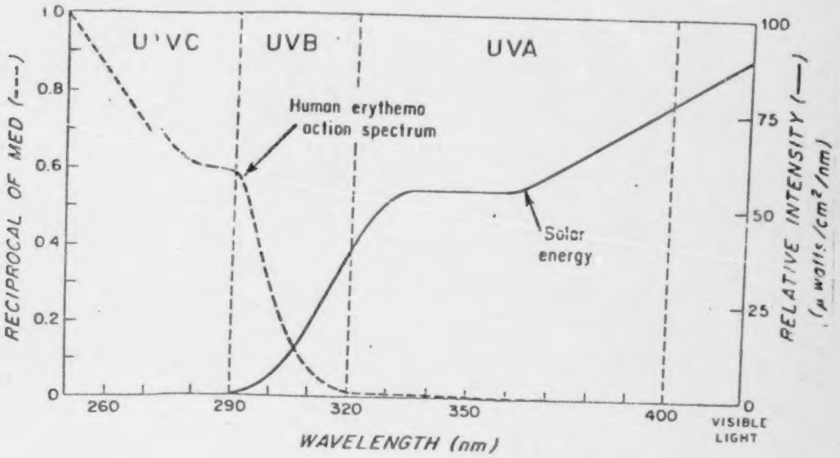

VISIBLE
VIOLET
RED
COSMIC RAYS
GAMMA RAYS
X-RAYS
ULTRAVIOLET
INFRARED
RADIO WAVES
X-RAYS
VACUUM UV
SHORT-WAVE UV (UVC)
MIDDLE WAVE UV (UVB)
LONG-WAVE UV (UVA)
VISIBLE LIGHT
100
200
300
400
WAVELENGTH IN NANOMETERS

Fig. 1-1. Electromagnetic spectrum with expanded scale of ultraviolet radiation.

Figure 2



Testimony presented July 23, 1981 to the Subcommittee on Toxic Substances and Environmental Oversight of the Senate Committee on Environment Public Works (Robert T. Stafford, Chairman), Washington, D.C.

THE EFFECTS OF CHLOROFLUOROCARBONS ON STRATOSPHERIC OZONE AND THE HEALTH EFFECTS WHICH MAY FOLLOW THEREFROM

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Solar radiation is a very important element in our environment, and yet, because of its ubiquity, the wide scope of its chemical and biological effects is often not fully appreciated. The fact that solar energy fixation makes life possible is widely known. It is not so generally appreciated that many of the effects of solar radiation are detrimental. Most people are aware that a painful sunburn can be caused by excessive exposure to the sun. There are also more subtle effects of sunlight on living cells, including the production of mutations. The development of skin cancer may follow sufficient chronic exposure to sunlight.

The shortwave portion of the solar spectrum is potentially very detrimental to plant and animal cells. A small amount of ozone in the upper atmosphere filters out these harmful wavelengths of UV light and, thus, prevents most such radiation from reaching the surface of the earth. The formation of this ozone shield in geologic time was most likely a prerequisite for the evolution of terrestrial life as we know it. However, even in the presence of this ozone layer, a biological significant amount of UV radiation does reach the surface of the earth.

Model calculations performed in the past decade have resulted in the suggestion of a parametric range for the potential decrease in stratospheric ozone due to various causes of from 1% to 50% (median 15%). A recent report of the National Academy of Sciences (NAS) entitled, "Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons" (NAS, 1979) estimates a median decrease in stratospheric ozone at equilibrium of 16.5%, assuming continuing discharge of chlorofluorocarbons (CFC) into the atmosphere.

More recent calculations, utilizing two-dimensional models and the latest rate constants for some chemical equations of importance, estimate a median decrease of stratospheric ozone, given present conditions of chlorofluorocarbon production and release, at approximately -6% of equilibrium.

Based on the admittedly inadequate epidemiologic data, this has given rise to estimates of increases in skin cancer ranging from a few thousand to many hundreds of thousands additional cases in the United States alone. The huge range in estimates results, in part, from the present uncertainty about the shape of the "biologic action spectrum" for skin cancer induction and the lack of precise knowledge of the amount of "carcinogenic" UV radiation reaching populations at risk. It is important to recognize tht projected estimates are based on available data and best estimates of their meaning. Additional surveys of natural UV insolation, analyses of additional epidemiologic data, and further experiments with animals would greatly reduce some of the uncertainty.

Although the potential effect of increased ultraviolet irradiance on man, particularly in the form of skin cancer, is a prominent and sensitive issue, impacts of this increased irradiance on organisms of terrestrial (both agricultural and non-agricultural) and aquatic ecosystems may ultimately be of much greater concern. Certainly, our understanding of the sensitivity of plants, invertebrates, and vertebrates to increases of UV radiance is not nearly as well developed as is the case for *homo sapiens.* Without a reasonable understanding of what a *unit decrease* in ozone means for the biosphere, there is no perspective upon which to base decisions concerning acceptability of "allowable" changes.

The major effects on humans of UVR in the UVB (320 to 280 nm) range are on the skin and the eyes. Acute effects consist of "sunburn," an inflammatory response of the tissues which may be no more than mild redness, or slight stinging of the eyes, or may develop into the equivalent of second degree (blistering) "burns." The acute effects of single overdoses of UVB are transient, heal without scarring, and in the skin lead to adaptive changes of skin thickening and pigmentation, which afford some degree of protection. The only established positive (beneficial) effect of UVB in humans is the production of vitamin D precursors in the skin, which are absorbed ito the bloodstream and prevent rickets, a serious vitamin deficiency disease. It should be recognized that most work has been on the harmful effects of UVB, and relatively little attention has been given to possible beneficial effects, however.

Repeated UVB exposure, prolonged over many years, can result in chronic degenerative changes in skin, characterized by skin "aging" and the development of premalignant and malignant lesions. The skin cancers of man can be broadly divided into two types: nonmelanoma skin cancer (NMSC) and malignant melanoma (MM).

There is excellent, although circumstantial, evidence that NMSC is primarily due to repeated exposure of the skin to UVB. The major arguments in favor of such a causal role of UVR in NMSC are:

> The most frequent locations of NMSC is on the most exposed skin sites (head, neck, arms, hands).
>
> Pigmented races, who sunburn much less readily than people with white skin, have much less NMSC and when it does occur, it does not affect the sun exposed sites.
>
> Among white skinned people, thos who spend more time outdoors and live in areas of greater UVR exposure (near the equator and in tropical and semitropical areas) have much greater risk for NMSC.
>
> Genetic diseases resulting in greater sensitivity to solar UVR are associated with premature NMSC development (albinism).
>
> Skin cancers of the NMSC type can readily be induced in the skin of experimental animals, and the upper wavelength limit for this is 320 nm, similar to the spectral range producing sunburn in man.

Recent epidemiologic research has resulted in the development of a preliminary dose-response relationship of NMSC to UVB. Reasonable assumptions, based on tissue culture and animal experiments, for the relationship of various wavelengths of UVR to NMSC induction have been proposed. While there is still discussion about the exact relationships of various parts of the UVR to carcinogenesis, existing data appear reasonably sufficient for the development of model systems that allow for some predictions as to the effect of reductions of stratospheric ozone to the probable increases in the incidence of NMSC secondary to increase in UVB.

Because of uncertainties in the amount of UVB actually reaching various populations, and because parts of any population are significantly more sensitive (for inherited reasons) to the chronic effects of UVR, estimates of possible NMSC increases have ranged from a few thousand to many hundred thousand of additional cases in U.S.A. alone. Projected estimates are based on available data (which is improving) and best estimates of their meaning (where considerable differences of opinion still exist).

In summary, there is reason to believe that most NMSC (but not all, for about one-third of basal cell cancer occurs in areas not receiving much UVB and not showing other sunlight damage) is causally related to chronic, repeated UVB exposure, and that a dose-response function exists that can, with considerable future refinement, be used to predict changes in NMSC incidence given alterations of the UVB climate.

The situation is somewhat different where MM is concerned. The NAS report (NAS, 1979) uncritically suggests that the relationship of MM to solar UVR exposure is basically similar to that of NMSC, and that the same model systems apply equally to NMSC and MM for predictive purposes.

There is considerable evidence that such assumptions are not tenable. The matter is of great importance, since MM is a serious, often (40%) fatal cancer. Although much less frequent in incidence, its potential ability to cause death makes it of greatest importance to attempt to develop a model for its causation, which may allow predictions as to future incidence to be made.

Because of its seriousness, recording of cases of MM is usually very good, so that epidemiologic studies that are quite reliable have been carried out in many countries in the past three decades. Very briefly, the following are the salient findings:

> There has been a consistent, worldwide increase in MM, incidence rates increasing 3 to 7% per year, leading to a doubling in 10 to 15 years. This trend for increasing incidence began with people born at or before the turn of the century, and has been progressively accelerating, so that younger persons have a greater risk for development of MM than older ones. This is very unusual behavior for a malignant tumor.
>
> There are striking differences in anatomic distribution by sex - MM is much more frequent on the backs of men and the lower legs of women. The incidence in those areas has been increasing rapidly, in contrast to MM of the head and neck area, and on the feet, which rose only slightly. This distribution is entirely different from that of NMSC.

Most MM is a disease of young adults. In contrast to NMSC, incidence of MM rises sharply during adolescence, plateaus in middle age, and rises again in old age. NMSC begins to appear in late middle age and rises sharply in old age.

In contrast to NMSC, only about 10% of MM (a subtype that closely resembles squamous cell cancer in its biologic behavior) show significant evidence of chronic solar skin damage.

While there are latitude gradients for MM within some countries, the normal gradient of increasing incidence from higher to lower latitudes is reversed in central Europe, and particularly in the Scandinavian countries, show incidence rates greatly in excess ofthose expected based on relative UVB intensity found at their latitude.

From available data, it appears that the latent period for MM development is short, perhaps even 3 to 5 years. The latent period for NMSC is certainly in excess of 20 years.

In contrast to NMSC, which affects mainly those chronically exposed to sunlight, i.e., outdoor workers, MM is much more frequent in white collar, educated, more affluent city dwellers.

As yet, no animal model for experimental production of MM exists using UVR. Only recently has it been possible to produce MM experimentally in guinea pigs, using a chemical carcinogen.

From the foregoing it is obvious that there are major differences in most features of NMSC and MM.

It is obvious that, if UVR is causally related to the development of MM, the mechanisms are very different. Certainly, except for the 10% Lentigo Maligna Melanoma that appears on the head and neck of old persons, most MM cannot reasonably be caused by the cumulative effect of repeated exposures to UVR, as is the case with NMSC. The various theories that have been proposed for its etiology are:

Related to UVR:

Exposure to intermittent, high dose exposure, presumably due to social changes, i.e., sunbathing, weekend gardening, golf, tennis, etc. and vacation trips to sunny places (Spain, North Africa, the Caribbean, etc.).

Production by UVR of a "circulating factor" which causes distant effects on precursor lesions.

"Initiation" of melanocytes, either by chemicals or UVR, with either UVR or chemicals acting as a "promoter" (i.e., two stage carcinogenesis).

"Promotion" of preexisting, abnormal precursor cells or lesions by UVR (precursor lesions perhaps genetically determined).

In any case, it is obvious that at this time, there is no possibility of assuming a reasonable dose-response relationship of UVR to MM development. In the absence of such information, attempts to predict what changes may take place in MM incidence if the intensity or spectrum of UVR changes are not appropriate.

There is certainly no rationale for using the models proposed for NMSC development secondary to UVR exposure for evaluation of MM changes. Calculations, using worst case assumptions based on NAS data, strongly suggest that a 5 year delay in regulation of CFC will not have a discernible effect on increases in incidence of NMSC or MM.

Recommendations for Research Studies Needed to Assess the Effects of Reduction in Stratospheric Ozone Layer Thickness on Biologic Systems, Particularly Humans

If policy makers are to have a solid data base on which to make regulatory decisions, and in order for scientists working in widely varying fields to be able to advise policy makers with reasonable accuracy, it is obvious that a functional, well-coordinated and managed, and adequately funded research program is urgently needed.

Since the problem of possible man-made alterations of the stratospheric ozone layer, with its concomitant in biologically effective ultraviolet radiation, was only seriously raised during the 1971 SST debate in Congress, and delineated by the report of the National Academy of Sciences Committee on Ultraviolet Radiation in 1973, very little time has elapsed during which these questions could be investigated. Only in the past 5 years have preliminary experiments been initiated to specifically address the question of the biological effects of increased UV-B irradiance. This work was mainly sponsored by the Climatic Impact Assessment Program of the Department of Transportation, which has now ceased to exist, and the EPA.

The reports of the CIAP (particularly Chapter 7, Volume 5, CIAP Reports) and of the Climatic Impact Committee of the National Academy of Sciences, have served to raise the questions to which answers are now needed.

Recommendation 1: Establishment of an interagency program, under the direction of a strong and capable lead agency.

Since a variety of man-made agents will most probably be capable of affecting the stratospheric ozone layer to some degree (SST's, conventional aircraft, fluorinated halocarbons, nitrogen fertilizers, bromine and chlorine containing compounds, atomic atmospheric explosions) and new agents are being discovered rapidly having this capability, many federal agencies have an obligation to support studies germane to this problem. Among these are the Departments of Transportation, Defense and Agriculture, The National Institutes of Health (particularly the National Cancer Institute, National Institute of Environmental Health Sciences and National Institue of Safety and Health) the Environmental Protection Agency, National Aeronautics and Space Administration, NOAA and ERDA.

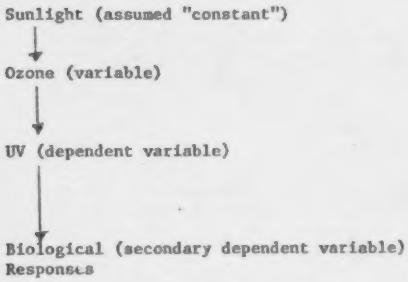
The most critical decision concerns the establishment of an effective arrangement for the management, coordination and implementation of an integrated research program.

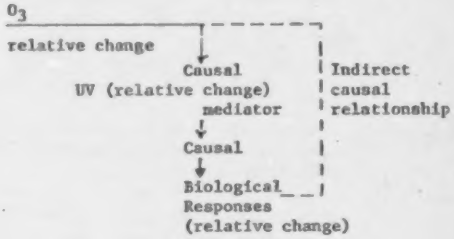
Effects of increased UV radiation on humans

The major effects on the biosphere may be due to reduction in the thickness of the ozone layer and the resulting increase in ultraviolet radiation shorter than 320 nm. Thus, the major recommendations for further research have to be considered within the terms of the possible ozone changes.

Given a primary variable (in this case ozone concentration), the generalizability of its relationship to a second (or lower) order dependent variable will depend on the understanding of intervening causal relationships.

Example: Ozone changes per se will not affect the incidence of skin cancer. However, since ozone changes will affect biologically active ultraviolet radiation, there will be a second-order association between ozone changes and biological effects. To the extent that either level of association is non-linear, the overall association will be complicated and difficult to extrapolate.


Sunlight (assumed "constant")
Ozone (variable)
UV (dependent variable)
Biological (secondary dependent variable) Responses


O_3
relative change
Causal
UV (relative change)
mediator
Causal
Biological Responses (relative change)
Indirect causal relationship

Outlined below are proposals by which useful quantitative information may be obtained (or be under way) in the next 2 to 5 years. The proposals are confined to work which is practicable in that period. These proposals aim to carry on the useful parts of work commenced under CIAP (which was essentially short-term in concept). There are plans to improve the accuracy and long-term reliability of quantitative observations such as UV exposure and skin cancer incidence. Special investigations have also been added to close the information gaps which have appeared in the CIAP data and to permit the drawing of meaningful conclusions.

Recommendations: Field Measurements and Instrumentation

Recommendation 2:
That more accurate data on present ozone levels be obtained particularly near sites where epidemiological data have been or will be collected.

Present Dobson ozone stations are scattered and make a limited number of observations. Satellite ozone estimation offers greater information over wider areas and longer periods. Comparison of relative pertinent usefulness of Dobson and satellite ozone measurement is required.

It must be anticipated that there will be processes other than the SST's and fluorinated halocarbons which may perturb the steady ozone state. There is thus an urgent need for ozone baseline data which are reliable, accurate and continuous. It is important to attribute any changes reliably to the correct cause.

Recommendation 3: Measurement of UV radiation reaching Earth

Accurate measurement of UV radiation reaching earth from sun and sky (direct and global) is necessary to:

- establish baseline levels
- establish the range of existing natural variation
- monitor for persistent changes resulting from various causes
- establish more reliably the relationship between ozone and effective UV for various biologic systems

a. Establish radiometric reference laboratories

Bener at Davos has completed extensive studies on sun and sky showing absolute intensities at all UV wavelengths and indicating apparent influences of altitude, ozone and elevation of the sun above the horizon. Measurements with a variety of other systems (Dobson, Robertson-Berger meters, etc.) are being carried out simultaneously and compared. This laboratory should be supported and a similar reference laboratory established at a more southerly location.

b. Establish a network of ground based stations for measurement of ultraviolet radiation

A network of UV-B meters (based on the design of Robertson as improved by Robertson and Berger) has been established under the auspices of CIAP and NOAA. These instruments automatically integrate the intensities of all UV-B wavelengths weighted to closely match the action spectrum for production of erythema in untanned white human skin. They are rugged, operate continuously with minimum attention, are relatively inexpensive and stable and give an immediate approach to the overall effectiveness of the sun's radiation as regards long-term damage to human skin.

Present UV-B meters are located (usually at weather bureau stations) at the following locations: Philadelphia, (Base) PA; Des Moines, IA: Minneapolis, MN; Bismarck, ND; Tallahassee, FL; Mauna Loa, HI; Brisbane, Australia; Aspendale, Australia; Davos, Switzerland. More recently, stations have been established at Honeybrook, PA; Copenhagen, Denmark; Poland and Italy. It is recommended that this network be continued and that after assessment of best locations for epidemiologic and meteorologic purposes, some instruments be relocated, and additional ones be established particularly at high (greater than 55° N) and low (less than 10° N) latitudes.

c. Correlation of ground-based ultraviolet radiation measurements with other parameters

It is urgently recommended that ground-based ultraviolet radiation measurements be correlated with ground-based ozone measurements (some of which have been performed at identical sites) and stratospheric ozone measurements (such as those obtained from the NASA atmospheric Explorer E satellite). A tie-in with stations measuring solar intensity for solar energy purposes is recommended.

d. Establish a central agency for acquisition, storage, correlation and interpretation of data, particularly of ground-based ultraviolet radiation, ozone thickness and local meteorologic conditions, with a view to provide such data and analyses to investigators in various disciplines and to perform long-term analyses.

e. Establish an advisory council on choice of instruments and location of stations for biologic and climatologic purposes

The present UV-B meters (Robertson-Berger type) are the only such measuring devices operating as a network and proven in long term field use. (See DHEW No. (NIH) 76-1029 report by the National Cancer Institute) These instruments can and should be improved to meet the more exacting requirements of a long term project.

A filter radiometer instrument designed by the Smithsonian Institution is being field tested and may have value for certain reference purposes. The proposed advisory council should be charged with decisions on long term use of appropriate instruments, considering the inherent capabilities of the two existing and other instruments certain to be proposed (e.g., UV radiometers presently used by NASA).

Recommendation 4: Development and use of personal ultraviolet radiation monitors

Population studies with personal monitors of UV-B radiation (such as the KPR type already studied in Switzerland) are needed to determine the fraction of daily ultraviolet dose delivered to the ground received by persons at risk for skin cancer. The amounts of the daily ultraviolet radiation dose actually received by human skin must vary greatly with occupation, behavior and local climatic conditions. Present knowledge of this factor is minimal, and the lack of this knowledge seriously interfers with the interpretation of existing data on the relationship of ultraviolet radiation to the development of skin cancer and chronic skin and eye damage. Development of personal ultraviolet monitors is an urgent priority project.

Recommendation 5: Improvement of high intensity ultraviolet radiation sources with narrow (monochromatic) and wide (solar simulator) spectra

One major problem in the application of ultraviolet radiation field measurement data to projection of changes in the incidence of skin cancer is the uncertainty of the shape of the action spectrum for skin carcinogenesis. Although the general direction and approximate limits of this action spectrum seem to parallel that of skin erythema, the fine structure of the carcinogenesis action spectrum is not known. The primary reason for this lack of information is the lack of high intensity, narrow band ultraviolet sources capable of irradiating relatively large areas (e.g., even the surface of one mouse). The development of high output tunable continous ultraviolet lasers, or possibly use of the ultraviolet radiation produced by the Stanford linear accelerator is of importance for such crucial studies. Better high intensity, large area solar simulators, which have been designed for space applications but presently are too expensive to use for chronic (1-2 year) animal experiments are also urgently required.

Recommendations: Epidemiology of Skin Cancer in Man

Recommendation 6: A program is needed to gather epidemiologic data on prevalence of nonmelanoma skin cancer over a wide span of latitudes

Since incidence data are extremely difficult to obtain accurately, prevalence data should be obtained at first. Areas of study should be separated by at least 300 miles north-south over a latitude span reaching beyond the most populated areas. Data should include age to first tumor, sex, occupation, skin phenotype and estimate of solar UV-B dose, obtained by personal dosimeters. It is of utmost importance that all these studies be performed to the same protocol, so that valid comparisons can be made. Promising areas for such studies, in addition to the United States, are Australia (particularly Queensland), Scandinavia and South Africa.

Recommendation 7: Identification of the population at greatest risk

Such population studies on the prevalence or incidence of skin cancer that do exist,suggest very strongly that persons with certain skin phenotypes (fair skin, light eyes, freckles, burn easily, tan poorly) have a higher risk for development of skin cancer than others, and that this a genetic trait (Celts).

Efforts should be made to develop simple screening methods for identification of the most susceptible among the population. UV-A photography (including TV screening), coupled with skin testing with solar simulators are promising for this purpose.

Recommendation 8: Epidemiologic studies of malignant melanoma

While much rarer than nonmelanoma skin cancer, Malignant melanoma is a serious cancer with a death rate similar to that of cancer of the breast (i.e., up to 40%). The relationship of malignant melanoma to ultraviolet radiation is less clear cut than that of nonmelanoma skin cancer, and thus a detailed study of the epidemiology, anatomic distribution and associated factors of this serious skin cancer is urgently needed. If the relationship of malignant melanoma to UV-B radiation can be established, the seriousness of increases in UV-B due to changes in the ozone layer is markedly greater.

Recommendations: Animal Experiments needed to study the relationship of ultraviolet radiation to the development of skin cancer

Recommendation 9: UV-B/solar spectrum interaction

A study is required of the effect of interaction between UV-B and the rest of the solar spectrum in relation to skin tumor development. This can be done by a subtractive technique removing spectral bands from a polychromatic beam of radiation. Experiment has already shown that this effect exists. It is particularly pertinent in this field where ozone reduction will affect UV-B only.

Recommendation 10: UV-B flux

Investigation is needed of the influence of change in flux of UV-B on skin carcinogenesis. Preliminary experiments show that protracting the delivery of a dose of UV (i.e., altering flux) has a significant effect on skin carcinogenesis. The direction of the effect is unexpected--lower flux can be more effective.

Recommendation 11: Intervals of UV exposure

It is recommended that the effect of varying interval periods during carcinogenesis experiments be studied in detail. The dose response model of

Blum, and the model for effect of "effective exposure" of Robertson, demonstrate that intervals of exposure are of importance in skin carcinogenesis. This may be one of the most important experiments, since in nature, change in ozone will affect flux and spectral distribution of UV but not the time relationship during which people will be exposed.

Recommendation 12: Development of centers of excellence

Ideally, biological studies of the impact of altered levels of ultraviolet irradiation should be conducted at all levels ranging from the molecular to the tissue, organ, organismal and ecosystem level. Nevertheless, fiscal and logistical constraints dictate an ordering of priorities in the types of experiments to be conducted.

In recommendations 1 - 11, an outline has been given of the types of studies required to determine the impact of alteration of ultraviolet radiation on man, irrespective of the source or mechanism of the cause of the alteration of ultraviolet radiation flux.

However, in order to understand and to either prevent or treat the undesirable effects of such an alteration, much needs to be known about events taking place at the molecular and cellular levels. Coordination and correlation of meteorologic, atmospheric, epidemiologic and experimental results are of greatest importance.

To accomplish the goals outlined, development of a few centers of excellence, spanning the entire field from instrumentation and optics to application to living higher systems are of major importance.

It is recommended that serious consideration be given to the development of such centers of excellence in the field of

1. Aquatic photobiology
2. Terrestrial plant photobiology
3. Human and animal photobiology
4. Atmospheric and meteorologic studies

A further great boon of such centers of excellence would be that they could serve as training centers in areas of their special expertise, a most important function since few scientists have special knowledge in these fields, and virtually no training programs in these areas now exist.

References

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9. Green, A.E.S., et al: The ultraviolet dose dependence of non-melanoma skin cancer incidence. Photochemistry and Photobiology 24:353-362, 1976.
10. National Acacemy of Sciences: Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons, Committee on Impacts of Stratospheric Change, Committee on Alternatives for the Reduction of Chlorofluorocarbon Emissions, Washington, D.C., 1979.

TESTIMONY OF

Myron F. Uman

before the

Subcommittee on Toxic Substances and Environmental Oversight
Committee on Environment and Public Works
United States Senate

July 23, 1981

My name is Myron F. Uman. I am Associate Executive Secretary of the Environmental Studies Board of the National Research Council, which is the operating arm of the National Academy of Sciences and National Academy of Engineering. I am also the senior staff officer responsible for the Academy's current study of the causes and effects of depletion of stratospheric ozone.

Since 1975, committees of the National Research Council have issued a total of eight reports on the causes and potential consequences of reductions in stratospheric ozone. Attachment A to my testimony is a list of these reports.

In April of this year, the Environmental Protection Agency asked the Academy to provide assistance to the agency in carrying out its responsibilities under Section 153(g) of the Clean Air Act, which requires the Administrator to report biennially to the appropriate committees of Congress on the results of studies and research conducted by EPA and other federal agencies. The Academy agreed to assist by providing the agency with assessments of the state of knowledge about ozone depletion and its effects, concentrating on changes in the state of knowledge since the preparation of the earlier NRC reports. Our report will be submitted to EPA by December 21st of this year so that EPA may in turn report to you on January 1, 1982.

To carry out its responsibilities, the Academy has divided the subject matter into two parts. In one part, we shall examine (a) changes in the state of knowledge of atmospheric processes and causes of ozone depletion and (b) capabilities for detecting changes in stratospheric ozone, including an assessment of trend analysis, sensitivity analysis, and uncertainties. This part is being performed by a Committee on Chemistry and Physics of Ozone Depletion chaired by Professor Charles Kruger of Stanford University. Attachments B and C respectively are the statement of task and member list of this committee. The committee will update existing reports but will not attempt to restate information that is already well known or to examine areas that are reasonably well understood. The committee will, of course, use all of the scientific information available to it, including that that has been gathered at a recent workshop under the joint auspices of the National Aeronautics and Space Administration and the World Meteorological Organization.

In the second part of the study, a Committee on Biological Effects of Increased Solar Ultraviolet Radiation will undertake a comprehensive examination of the state of knowledge of the effects of changes in concentrations of stratospheric ozone on plants, fish and other aquatic organisms, terrestrial and aquatic ecosystems, and human health. This committee is chaired by Dr. Richard Setlow of the Brookhaven National Laboratory. Attachments D and E respectively are the statement of task and member list of this committee. Dr. Setlow's committee will conduct a workshop of leading researchers in this field in Washington on July 30-31. Attachment F is the preliminary agenda of the workshop.

I regret that the timing of our work and these hearings are such that the Academy is unable to present its results at this time. We shall be happy to provide that testimony early next year.

Thank you.

NAS Studies of Depletion of Stratospheric Ozone

Date of Issue	Report	Chairman
1973	Biological Impacts of Increased Intensities of Solar Ultraviolet Radiation	Kendric C. Smith
1975	Environmental Impact of Stratospheric Flight	Henry G. Booker
1976	Halocarbons: Environmental Effects of Chlorofluoromethane Release	John W. Tukey
1976	Halocarbons: Effects on Stratospheric Ozone	H.S. Gutowsky
1977	Response to the Ozone Protection Sections of the Clean Air Act Amendments of 1977: An Interim Report	John W. Tukey
1978	Nitrates: An Environmental Assessment	Pat L. Brezonik
1979	Stratospheric Ozone Depletion by Halocarbons: Chemistry and Transport	Harold L. Schiff
1979	Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons	John W. Tukey Max S. Peters

COMMISSION ON NATURAL RESOURCES
ENVIRONMENTAL STUDIES BOARD
Committee on Chemistry and Physics of Ozone Depletion

Statement of Task

The Committee is organized in response to a request from the U.S. Environmental Protection Agency to provide an assessment of changes in the state-of-knowledge since the publication of earlier NRC reports on ozone depletion and its effects. The earlier reports include "Stratospheric Ozone Depletion by Halocarbons: Chemistry and Transport," "Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons," "Halocarbons: Environmental Effects of Chlorofluoromethane Release," "Halocarbons: Effects on Stratospheric Ozone," "Environmental Impact of Stratospheric Flight," and "Nitrates: An Environmental Assessment."

The Committee on Chemistry and Physics of Ozone Depletion will update these reports by examining:

(1) changes in the state-of-knowledge of atmospheric processes and of causes of ozone depletion, and

(2) capabilities for detecting changes in stratospheric ozone, including an assessment of trend analysis as applied to detecting stratospheric ozone changes.

Another committee has been formed to examine current knowledge of the potential effects of increases in ultraviolet radiation on humans and other biological systems resulting from depletion of stratospheric ozone.

The Committee on Chemistry and Physics of Ozone Depletion will perform its task by commissioning a series of papers on specific topics where significant advances in understanding have taken place. These papers will be subjected to peer review. The Committee will prepare a summary of the papers and an overview of the subject which, along with the completed papers, will be submitted to the agency by December 21, 1981.

COMMITTEE ON CHEMISTRY AND PHYSICS OF OZONE DEPLETION

Members

CHARLES H. KRUGER, JR., Chairman, Department of Mechanical Engineering, Stanford University, Stanford, CA.: rarefied gas dynamics; air pollution; environmental decision making. Member of the Environmental Studies Board of the National Research Council.

ROBERT E. DICKINSON, National Center for Atmospheric Research, Boulder, CO.: meteorology; dynamics of the upper atmosphere; models.

JAMES P. FRIEND, Department of Chemistry, Drexel University, Philadelphia, PA.: atmospheric chemistry; atmospheric diffusion; global cycles and geochemistry of trace materials in the atmosphere.

DONALD M. HUNTEN, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ.: atmospheric sciences; spectroscopy; earth's upper atmosphere; photoelectric and spectroscopic instrumentation. Member of the National Academy of Sciences.

MICHAEL B. MCELROY, Center for Earth and Planetary Physics, Harvard University, Cambridge, MA.: applied mathematics and physics; physics and chemistry of planetary atmospheres.

Consultants

JAMES G. ANDERSON, Center for Earth and Planetary Physics, Harvard University, Cambridge, MA.: astrogeophysics; observations of chemical species in the earth's stratosphere; development of techniques for detecting chemical species in the stratosphere and troposphere.

RALPH J. CICERONE, National Center for Atmospheric Research, Boulder, CO.: atmospheric chemistry and physics; photochemistry of stratospheric ozone; numerical models; atmospheric trace gases.

HANS A. PANOFSKY, Department of Meteorology, Pennsylvania State University, University Park, PA.: dynamic meteorology, impacts on climate, perturbations of the atmosphere.

A. BARRIE PITTOCK, CSIRO Division of Atmospheric Physics, Mordialloc, Victoria, Australia: Atmospheric science; stratospheric circulation; ozone behavior and climatology; climate change and variability.

STEVEN C. WOFSY, Center for Earth and Planetary Physics, Harvard University, Cambridge, MA.: stratospheric chemistry; photochemistry; trace gases containing carbon; temporal and spatial variations of trace gases in the stratosphere.

COMMISSION ON NATURAL RESOURCES
ENVIRONMENTAL STUDIES BOARD
Committee on Biological Effects of Increased Solar Ultraviolet Radiation

Statement of Task

Under contract no. 68-02-3701 with the U.S. Environmental Protection Agency, the National Research Council's Environmental Studies Board is appointing a Committee on Biological Effects of Increased Solar Ultraviolet Radiation. The Board has agreed to provide EPA with an assessment of the state of knowledge about biological effects of stratospheric ozone depletion. One consequence of ozone depletion is an increase in the intensity of solar ultraviolet radiation reaching the earth's surface. The Committee's task is to undertake a comprehensive evaluation of what is known about the biological — environmental and human health -- effects of increased intensities of solar UV-B radiation.

The Committee will concentrate on current understanding of UV-B radiation effects on terrestrial and aquatic plants, fish and other aquatic organisms, ecosystems, and human health (examining clinical and epidemiological data and data obtained with animal models) so that statements of biological effects of ozone depletion can be brought to a level more closely approximating the already sophisticated understanding of chemical and physical processes in the atmosphere. The Assembly of Life Sciences and the Committee on National Statistics (ABASS) will be kept informed of the ESB study and invited to contribute and participate where appropriate.

Several recent NRC studies have examined the biological effects of increased solar UV radiation that might result from predicted stratospheric ozone depletion, producing reports on Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons (1979), Halocarbons: Environmental Effects of Chlorofluoromethane Release (1976), and Environmental Impact of Stratospheric Flight (1975). The present study will update these reports.

The Committee's report is due to EPA December 21, 1981.

COMMITTEE ON BIOLOGICAL EFFECTS OF INCREASED SOLAR ULTRAVIOLET RADIATION

RICHARD B. SETLOW, *Chairman*, Biology Department, Brookhaven National Laboratory, Upton, N.Y.: molecular biophysics; ultraviolet spectroscopy; action of light on proteins, viruses, and cells; repair mechanisms. Member of National Academy of Sciences.

JAMES P. FRIEND, Department of Chemistry, Drexel University, Philadelphia, PA.: atmospheric chemistry; atmospheric diffusion; global cycles and geochemistry of trace materials in the atmosphere.

MAUREEN M. HENDERSON, Health Sciences Center, University of Washington, Seattle, WA.: epidemiology. Member of Institute of Medicine.

JOHN JAGGER, Department of Biology, University of Texas at Dallas, Richardson, TX.: photobiology; effects of radiation on large molecules and cells; effects of ultraviolet on bacteria; effects of near ultraviolet on cell growth and membrane function.

RICHARD M. KLEIN, Department of Botany, University of Vermont, Burlington, VT.: plant physiology, photobiology, growth and development of plants.

JOHN PARRISH, Department of Dermatology, Harvard Medical School and Massachusetts General Hospital, Boston, MA.: dermatology, melanoma, ultraviolet as a treatment for psoriasis.

HOWARD H. SELIGER, Department of Biology, The Johns Hopkins University, Baltimore, MD.: photobiology; photemetry; bioluminescence; excited states of biological molecules; marine biology of bioluminescent dinoflagellates.

WILLIAM SISSON, Department of Animal Range Science, New Mexico State University, Las Cruces, NM.: effects of ultraviolet on plants and ecosystems; desert and rangeland ecosystems.

PRELIMINARY AGENDA

Workshop on

BIOLOGICAL EFFECTS OF INCREASED SOLAR ULTRAVIOLET RADIATION

July 30-31, 1981
National Academy of Sciences
Washington, D.C.

Richard B. Setlow, Chairperson

SESSION I:	MOLECULAR AND CELLULAR EFFECTS July 30, 1:00 p.m. - 9:30 p.m., Dinner 5:30 - 7:30 p.m. Lecture Hall, NAS Bldg., 2101 Constitution Ave., N.W.
SESSION II:	ECOSYSTEM EFFECTS July 31, 9:00 a.m. - 5:30 p.m., Dinner 5:30 - 7:00 p.m. Room 600A, Joseph Henry Bldg., 2100 Pennsylvania Ave., N.W.
SESSION III:	HUMAN HEALTH EFFECTS July 31, 8:30 a.m. - 9:00 p.m., Dinner 5:30 - 7:00 p.m. Room 200A, Joseph Henry Bldg., 2100 Pennsylvania Ave., N.W.

SESSION I: MOLECULAR AND CELLULAR EFFECTS

Richard B. Setlow, Chairperson
John Jagger, Cochair

July 30, Lecture Hall, 2101 Constitution Avenue, N.W.

1:00 p.m. - 1:15 p.m.	Introductory remarks; review of agenda.
1:15 p.m. - 1:30 p.m.	EPA's interest. H.L. Wiser
1:30 p.m. - 1:45 p.m.	Description of the NRC study and charge to the Committee on Biological Effects of Increased Solar Ultraviolet Radiation; Workshop objectives. R.B. Setlow
	- DISCUSSIONS -
1:45 p.m. - 2:15 p.m.	What was known in 1976 and previous studies. What further information was felt to be needed. R.B. Setlow
2:15 p.m. - 2:45 p.m.	UV damage to the DNA of skin cells and its repair. R.B. Setlow
2:45 p.m. - 3:15 p.m.	The wavelengths important in affecting DNA. J. Doniger
3:15 p.m. - 3:30 p.m.	UV-B and UV-A effects on all other cell processes. J. Jagger
3:30 p.m. - 4:00 p.m.	UV-B and UV-A effects -- interaction among several wavelengths (bacteria). R.B. Webb
4:00 p.m. - 4:30 p.m.	The effects of polychromatic light on cellular systems (mammalian). M.M. Elkind
4:30 p.m. - 5:00 p.m.	The wavelengths affecting the immune system of mice. E. deFabo
5:00 p.m. - 5:30 p.m.	Dose-response relations for animals, solar simulators -- dose rate effects. P.D. Forbes
5:30 p.m. - 7:30 p.m.	COCKTAILS AND DINNER Rotunda for cocktails, Refectory for dinner, NAS Bldg. 2101 Constitution Ave., N.W.
7:30 p.m. - 9:30 p.m.	General discussion and conclusions.

SESSION II: ECOSYSTEM EFFECTS

Howard H. Seliger, Chairperson
William B. Sisson, Cochair

July 31, Room 600A, 2100 Pennsylvania Avenue, N.W.

9:00 a.m. - 9:30 a.m.	Introductory remarks. H.H. Seliger What was known in 1976 and previous NAS studies. What further information was felt to be needed. H.H. Seliger
	- DISCUSSIONS -
9:30 a.m. - 9:45 a.m.	General introduction to problems of ecosystem analysis. L.B. Slobodkin
9:45 a.m. - 10:15 a.m.	Larval physiology, marine systems. J.R. Hunter
10:15 a.m. - 10:45 a.m.	Marine phytoplankton, productivity. R.C. Worrest
10:45 a.m. - 11:15 a.m.	Specific UV effects in freshwater and marine ecosystems. J. Calkins
11:15 a.m. - 11:45 a.m.	UV effects in cattle and other animals. K. Kopecky
11:45 a.m. - 12:15 p.m.	Plant growth and physiology. R.H. Biggs
12:15 p.m. - 1:30 p.m.	LUNCH 2nd Floor Dining Room, Joseph Henry Building 2100 Pennsylvania Avenue, N.W.
1:30 p.m. - 2:00 p.m.	Physiological ecology. A. Teramura
2:00 p.m. - 2:30 p.m.	Plant ecology and general comments. W.B. Sisson
2:30 p.m. - 3:00 p.m.	Impressions of how the above information might fit into ecosystem models. L.B. Slobodkin
3:00 p.m. - 5:30 p.m.	General discussion and conclusions.
5:30 p.m. - 7:00 p.m.	COCKTAILS AND DINNER Adam's Rib Restaurant 2100 Pennsylvania Avenue, N.W.

SESSION III: HUMAN HEALTH EFFECTS

Maureen M. Henderson, Chairperson
John A. Parrish, Cochair

July 31, Room 200A, 2100 Pennsylvania Avenue, N.W.

NONCANCER EFFECTS

8:30 a.m. - 8:45 a.m.	What was known in 1976 and previous NAS studies. J.A. Parrish
8:45 a.m. - 9:10 a.m.	Normal and abnormal cutaneous photobiology (human). J.A. Parrish
9:10 a.m. - 9:35 a.m.	Actinic degeneration. A.M. Kligman
9:35 a.m. - 10:00 a.m.	Ultraviolet photobiology of the eye. S. Lerman
10:00 a.m. - 10:30 a.m.	- DISCUSSION & BREAK -

EXPERIMENTAL PHOTOCARCINOGENESIS

10:30 a.m. - 11:20 a.m.	Dosimetric parameters and mechanisms. P.D. Forbes
11:20 a.m. - 12:00 noon	Immunologic aspects. M.L. Kripke
12:00 noon - 12:20 p.m.	- DISCUSSION -
12:20 p.m. - 1:30 p.m.	LUNCH 2nd Floor Dining Room, Joseph Henry Building 2100 Pennsylvania Avenue, N.W.

EPIDEMIOLOGY OF PHOTOCARCINOGENESIS

Nonmelanoma Skin Cancers

1:30 p.m. - 1:35 p.m.	What was known in 1976 and previous NAS studies. M.M. Henderson
1:35 p.m. - 1:55 p.m.	Update on skin cancer incidence. J. Scotto
1:55 p.m. - 2:15 p.m.	Update on skin cancer incidence in cohort treated with phototherapy. R.S. Stern
2:15 p.m. - 3:05 p.m.	Prediction of skin cancer mortality and morbidity rates from ultraviolet exposure. E.L. Scott
3:05 p.m. - 3:35 p.m.	- DISCUSSION & BREAK -

Melanoma

3:35 p.m. - 3:40 p.m.	What was known in 1976 and previous NAS studies. M.M. Henderson
3:40 p.m. - 4:00 p.m.	Prediction of rates of melanoma through ultraviolet exposure. E.L. Scott
4:00 p.m. - 4:20 p.m.	Discussion of review paper updating the epidemiology of melanoma. D. Strickland
4:20 p.m. - 4:40 p.m.	Familial aggregation of melanomas. S. Graham
4:40 p.m. - 5:00 p.m.	Dysplastic mole syndrome. M. Green
5:00 p.m. - 5:20 p.m.	Update on predictive factors for melanomas. A. Sober
5:20 p.m. - 5:30 p.m.	- DISCUSSION -
5:30 p.m. - 7:00 p.m.	COCKTAILS AND DINNER Adam's Rib Restaurant 2100 Pennsylvania Avenue, N.W.
7:00 p.m. - 9:00 p.m.	General discussion and conclusions and priorities for research.

STATEMENT OF THE NATURAL DEFENSE COUNCIL, INC., ALAN S. MILLER, STAFF ATTORNEY, AND DR. KARIM AHMED, STAFF SCIENTIST

Summary

After six years of intensive, worldwide research, substantial scientific evidence supports the hypothesis that chlorofluorocarbon emissions will damage the ozone layer in the stratosphere. The potential adverse impact on human health, marine and agricultural productivity, and climate is substantial.

EPA has to date acted with great sensitivity to the potential impact of regulation on industry. The Agency's issuance of an Advance Notice of Proposed Rulemaking was a commendable effort to obtain information from industry and the public on the feasibility of alternative regulatory approaches.

In the Clean Air Act Amendments of 1977, Congress appropriately mandated that EPA give first priority to public health risks in formulating ozone protection policy, although the feasibility and costs of controls must also be considered. Proposed industry-sponsored amendments would shift this balance dramatically to prevent any form of new regulation.

The amendments make no allowance for the possibility of new evidence of public health risks short of verification of ozone depletion, which scientists believe is ten years away. The proposed alternative triggers for regulation are unworkable as well as poor policy. No form of regulation would be allowed if the amendments are adopted, no matter how cautiously applied or limited in economic impact.

The Natural Resources Defense Council is a national, nonprofit conservation organization with more than 40,000 members in the U.S. and more than 20 other countries. NRDC recognizes the importance of global resources as well as domestic environmental problems, and for that reason we have worked for policies to protect the ozone layer for many years. We filed the initial petitions with the Food and Drug Administration and the Consumer Product Safety Commission which ultimately led to the ban on use of chlorofluorocarbons (CFCs) for aerosol sprays.

With me today is Dr. Karim Ahmed, a Ph.D. chemist and staff scientist at NRDC. Dr. Ahmed is one of several staff members who have been deeply involved in the formulation of hazardous chemical control policies at a professional level. NRDC staff members serve on several relevant EPA Advisory Committees, on technical committees of the Organization for Economic Cooperation and Development (OECD), and on numerous professional bodies. NRDC's involvement in the CFC issue also reflects a commitment to help resolve the difficult, complex policy issues inherent in chemical regulatory policy. With the assistance of several staff members and outside experts, I prepared a twelve-country comparative study of fluorocarbon regulation funded by the German Government. Conclusions were presented at an international meeting of governments on the CFC problem held in Munich in December 1978. NRDC was the only nongovernmental organization invited to participate, and the study was subsequently published as a book.

My testimony today will address two general topics of concern at this hearing, the environmental impact of ozone depletion and the appropriate framework for formulating a government response. My comments draw on the analysis submitted to EPA by NRDC and several other environmental organizations in response to the Advance Notice of Proposed Rulemaking on ozone-depleting chlorofluorocarbons (45 Federal Register 66726, October 7, 1980). A copy of these comments has been given to the subcommittee with my testimony.

A. Environmental Impacts of Chlorofluorocarbon Emissions

The hypothesis that release of chlorofluorocarbons might result in depletion of the ozone layer of the stratosphere has been subjected to intensive worldwide scrutiny for more than six years, including unusually extensive international cooperation. Two National Academy of Sciences reports have been done on the issue and a third is now in progress. The latest scientific information is regularly collected and communicated through the United Nations Environment Program and the World Meteorological Organization. Economic and social implications of regulation have been studied by the Organization for Economic Cooperation and Development and discussed at several ad hoc meetings of the largest CFC-producing nations. After all this effort, the issues are as serious and challenging today as they were in 1974. As stated in a 1981 draft report by the OECD, "the basic formulation of stratospheric chlorine chemistry remains unchanged from that originally put forward by Molina and Rowland in 1974." The problem can be ignored, but it cannot be legislated away.

Since EPA's publication of the Advance Notice, considerable attention has been focussed on the economic importance of CFCs. Unfortunately, much less discussion has occurred concerning the risks associated with not restricting CFC emissions. This hearing will perhaps partly offset this imbalance.

There are two primary categories of risks created by ozone depletion, direct results of increased exposure to damaging ultraviolet light (DUV), and indirect results of the expected temperature increase in the troposphere and temperature drop in the stratosphere. As other testimony in this hearing is likely to explain, these problems are essentially independent. The effect of DUV is due to a change in column ozone, that is, the amount of ozone in a vertical column of the atmosphere. Temperature changes, however, could be caused by a change in the distribution of CFCs and ozone within the column, even if total column ozone is largely the same. This could occur if ozone is added to the atmosphere at one level but removed at another, precisely the scenario currently envisioned by some scientists. Ozone could be added in the troposphere as a consequence of subsonic aircraft and removed in the stratosphere due to CFCs. (As one can imagine, this makes the problem of sorting out what is actually going on considerably more difficult; ground level measurements of ozone, the principal measurement we now have, can detect only changes in column ozone.) As will be explained, our understanding of the risks associated with DUV exposure is much greater than our knowledge of those created by temperature shifts, but both present serious case for concern.

1. Risks of Increased DUV

The relationship between ozone depletion and increased DUV exposure is known to vary with latitude and season, and is also non-linear (the rate of increase in DUV is greater than the rate of increase in ozone depletion). Because of the long lead times associated with both the release of CFCs from some applications (*e.g.*, rigid foams) and the slow transport of CFCs to the stratosphere, the increase in DUV will also follow by some years their commercial use, and then will continue for as much as forty years or longer. The latitudinal and seasonal differences have an important impact on the distribution of the increased DUV dose:

> Ozone concentrations tend naturally to be higher, and the UV-B levels lower, at high latitudes and during the winter. This is also where and when the 2-D models predict that the greatest decreases in ozone, and hence highest increases in UV-B, will occur. Ozone depletion will fall off as summer approaches, but significant depletion will still occur in spring, a period when young plants, and fish eggs and larvae, which are most sensitive to UV-B radiation, are rapidly developing.

Organization for Economic Cooperation and Development, *Report on Chlorofluorocarbons* (March 1981 draft) ¶72, pp. 21-23. Thus, for a given level of depletion, the risks associated with increased DUV will increase with latitude.

There are human and non-human risks associated with increased DUV. An increase in skin cancer is the risk most frequently discussed, probably because of the clear relationship between DUV and skin cancer. As our comments to EPA indicate in some detail, there is now extensive evidence[1] that nonmelanoma skin cancer is related to lifetime accumulated DUV exposure in susceptible populations. In general, an increase in skin cancer of four percent is expected for every percent of ozone depletion, but this effect will increase at higher levels of depletion and will not be distributed evenly geographically or among ethnic groups. In any case, thousands of new skin cancers would be caused by any measurable amount of ozone depletion.

The evidence connecting rare but frequently fatal melanoma (skin cancer) and DUV is less clear but merits attention. Malignant melanoma is thought to be more closely related to brief exposures of high intensity UV radiation than cumulative lifetime exposure. Thus, the incidence of melanoma could also be increased by ozone depletion.

Much less attention has been given to other potentially adverse health effects of ozone depletion. However, DUV is also blamed for some forms of cataracts.

Increased DUV is also a concern because of less studied but potentially catastrophic impacts on marine and agricultural productivity. Recent evidence indicates that DUV has adverse effects on phytoplankton and on larval and juvenile stages of many commercially valuable fish. This damage would be multiplied up the food chain, with unpredictable but clearly undesirable results. Similarly unpredictable but highly risky changes could

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1/ "Indisputable" evidence, according to the NAS report in 1979.

also occur in agricultural productivity because of variations in the response of plants to DUV. Agriculture would also be affected by any change in climate as discussed below.

2. Risks of Temperature Shifts

As explained above, column ozone might be unaffected by CFCs while the distribution of ozone changes considerably. This would mean a temperature increase at one level and a temperature drop at another since the quantity of ozone affects the surrounding temperature. Since activities in the stratosphere are thought to have a significant impact on climate, the potential effect could be changes in climate currently beyond our predictive abilities. The risks of changes in rainfall, temperature, etc., are without question of a high magnitude; merely because they are difficult to predict and quantify does not indicate they are not real.

B. Formulating a Government Ozone Protection Policy

The CFC problem is undoubtedly one of the most difficult currently before EPA. The risks are great but currently beyond verification, and prospects for resolving the uncertainties before substantial irreversible damage occurs are poor. According to draft United States comments on the OECD chlorofluorocarbon report dated July 10, "it is unlikely that [ozone depletion] would be observable within at least the next ten years" barring unexpected changes in technology. At the same time, the potential costs of regulation are also a matter for concern, and unilateral action by the United States can ameliorate but not solve the problem. Yet this situation is not unique. Similar difficulties are associated with the issues of acid rain and emissions of CO_2, and no doubt other questions will arise concerning the impact of man's activities in the future. Decisions made concerning ozone portection must therefore be viewed in terms of a broader policy toward the type of procedure appropriate to resolve such controversies.

This Committee has been asked to make sweeping changes in the legislation which currently governs EPA determination of CFC policy. Under Section 157 of the Clean Air Act, EPA is currently directed to implement regulatory measures if the Agency finds any substance "may reasonably be anticipated to endanger public health or welfare. . . ." The Act also requires that the feasibility and costs of achieving controls be taken into account. Congress thus recognized the need to give first priority to public health risks in responding to potentially catastrophic damage to the global ecosystem. While consideration must be given to costs, EPA was given discretion consistent with the complex technical nature of the underlying scientific issues and the difficulty of obtaining conclusive proof before unacceptable damage occurs. The evidence supporting regulation was expected to be "reasonably reliable in light of known information and available time for gathering the data." House Conference Report No. 564, 95th Cong., 1st Sess., p. 100 (1977).

The proposed amendments in essence would require verification of the ozone depletion theory or an international agreement before EPA could propose further regulations, and even then such regulations would be subject to a veto by either house of Congress. The clear assumption underlying the proposal is that EPA cannot be trusted to balance the risks of ozone depletion and the costs to industry. We believe this is poor policy and not justified by the actions so far taken by EPA.

If EPA's response to the 1977 mandate had been to ignore economic consequences or to adopt hastily drafted regulations, Congress might have cause to dictate more specific policies to the Agency. However, this is not the case. EPA waited more than two years for an assessment of the issue by the National Academy of Sciences. During that time (and subsequently) research continued. The Agency has *not* decided whether or not to propose further regulations. The Advance Notice of Proposed Rulemaking, as stated in EPA testimony last week, "is an information gathering tool . . . which notified the public that EPA is concerned about the projected growth of CFCs and possible resultant effects on human health and the environment." In our estimation, this was the most conservative, responsible course; we believe EPA *should* have proposed a production cap. It would indeed be ironic if an Agency were to find its authority curtailed as a consequence of seeking comments on the feasibility of regulation. Given the evidence supporting the theory and the risks created by adopting a policy of no action, EPA would be irresponsible if it did not examine the feasibility of regulatory options. Moreover, all EPA policies are under review by the new Administration and no one has yet claimed that this Administration responds too hastily to public health risks.

EPA has clearly not been insensitive to the concerns of industry. With assistance from the RAND Corporation, studies were done of the availability of alternatives to CFCs and the costs of various regulatory scenarios. The RAND study concluded that the cost of a zero growth strategy, using the assumptions thought most reasonable, was less than $300 million over a ten year period. Worst-case assumptions increased the figure to $600 million over ten years, an acceptable amount in the context of a multi-billion dollar industry. The effect on Gross National Product, the Consumer Price Index, and other macroeconomic indicators would be negligible.

While industry argues that certain aspects of the study understate the costs of regulation, several assumptions tended to overstate costs.[2] To cite one example, the study was prepared with industry data, and as the RAND authors note, "there may be a tendency for firms to overestimate the costs." It is also the threat of regulation which experience demonstrates most effectively induces the development of substitutes and emission control devices necessary to reduce economic impacts. Without the threat of regulation, industry has little incentive to invest in non-CFC based technologies like the Rovac system to be described at this hearing. The study also does not include a cost estimate reflecting the possibility (or probability in statistical terms) that regulation at some future date - perhaps after "verification" has occurred - would cost considerably more. This is likely to be the case because

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2/ For a summary of the reasons, see pp. 33-37 of NRDC's comments on the ANPR.

the amount of CFCs in use will be greater[3] and a rollback proportionately more costly, and because once verification has been obtained public pressure for large cuts in emissions will be intense.

Thus, EPA has not slighted industry concerns but has engaged in exactly the sort of careful study and open comment procedure expected by Congress. A fair characterization of the record on economic issues would recognize legitimate differences in opinions at an early stage of the proceeding - surely not cause for Congressional intervention in EPA's handling of the issue.

More fundamentally, legislation creating narrowly defined factual conditions for the imposition of regulation in any form to protect the public against a serious environmental risk would be bad policy and a dangerous precedent. Given the magnitude of the rsiks, the first priority must continue to be public health. The proposed amendments would not allow regulation even if the risks were calculated to be orders of magnitude greater than the costs.[4] The two circumstances in which regulation could be proposed, detection of ozone depletion or the signing of an international agreement, make no allowances for any change in scientific understanding of the risks or revised estimates of the costs to industry. Both can be expected to

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3/ If the amount of CFCs in use is not likely to increase, there should be no reason to oppose a production cap.

4/ The application of cost-benefit analysis to the CFC issue is discussed in the 1979 NAS Report. National Academy of Sciences, Protection Against Depletion of Stratospheric Ozone By Chlorofluorocarbons, pp. 256-269 (1979).

change based on past experience. At the very least, regulations might be proposed with less impact than a production cap that nevertheless demonstrate the government's continued commitment to protecting public health. No such possibility is allowed under the proposed amendments.

Finally, even if Congress wished to more narrowly define EPA's powers to respond to health risks of ozone depletion, it would be difficult to craft more unworkable criteria than the two proposed in the amendments. They are ambiguous and only weakly related to the underlying policy issues.

The detection of actual ozone depletion is currently beyond the capacity of our data collection and measurement instruments. Although data is being collected and the methodologies for this purpose are being refined, the best estimate is that, based on current predictions of ozone depletion, it will be ten years before detection is possible (see p. 6). Even this estimate assumes a certain level of modelling accuracy which may not be borne out. We have to be able to say with confidence what ozone levels should have been before we can say that depletion has occurred. Apart from the physical difficulty of the task, the meaning of "detection" is open to argument. It could be plausibly contended that existing satellite data already offers evidence of depletion, and as a physical measurement this could be considered "detection." As I have already argued, this test also ignores the potential for substantial irreversible damage preceding detection. The ozone layer would continue to be depleted for decades because recovery is very gradual, because CFCs "banked" in foams and refrigeration systems will be released for a long period of time, and because regulations would take time to develop and implement. A detection requirement must be based on the questionable belief that depletion will not occur to justify taking such an enormous risk.

The alternative basis for regulation, conclusion of an international agreement, is equally unworkable and inappropriate. EPA has actively worked for international cooperation on CFCs since hosting a meeting of governments from major CFC-producing nations in early 1977. Since that time Canada, Sweden, and Norway have banned most aerosol propellant uses of CFCs; the Netherlands has imposed a warning label requirement; and the European Economic Community has adopted a cap on new production capacity and a cutback in the use of CFCs in aerosols of 30% from 1976 levels by the end of this year. Japan has also reached agreement with its industry concerning a voluntary cap on new production capacity, while many other countries have substantially reduced use of CFCs in aerosol propellants without regulation. The most significant recent action internationally was a decision by the Governing Council of the United Nations Environment Program to convene a working group on the subject of an international convention to protect the ozone layer.

While it is essential that U.S. efforts toward a cooperative approach continue, there is no argument for conditioning our actions on the policies of other governments. As our comments to EPA on the ANPR discuss in some detail, there is very little disagreement about our scientific understanding among scientists around the world. The disagreement concerns the appropriate policy response, an assessment that will inevitably vary among nations. Moreover, the U.S. is the largest consumer of CFCs and thus has some responsibility to exercise a leadership role. Our use of CFCs in automobile air conditioning is often a sore point with other countries, who tend to view this application as an unnecessary luxury. Unilateral action by the U.S., because we are such a large CFC user, would make a significant contribution to reducing ozone depletion, and if we develop substitutes as a result, there may even be an economic advantage as other countries gradually follow suit. Finally, the meaning of an "international agreement" requirement is also subject to wide differences of interpretation. We must seek international cooperation but, as in other areas of government policy, not depend upon it for our welfare.

Supplemental Comments of the
Natural Resources Defense Council

Hearings on the Impact of Chlorofluorocarbon Emissions on the Stratosphere before the Toxic Substances and Environmental Oversight Subcommittee of the Senate Committee on Environment and Public Works

July 23, 1981

These comments respond to several points made by industry witnesses at the hearing in addition to the six questions asked of the industry panel by Senator Gorton.

A. Responses to Industry Allegations

Allegation 1: There is no scientific consensus; foreign experts differ with their American counterparts.

Response: As the scientific presentations at the hearing suggested, there is in fact a remarkable degree of agreement among scientists. Moreover, this consensus exists on an international scale through the fora provided by the scientific updates done by the U.N. Coordinating Committee on the Ozone Layer (CCOL), the World Meteorological Organization (WMO), and the Organization for Economic Cooperation and Development (OECD). The process of consensus building is also specifically supported by U.S. agencies. NASA, cosponsored an international workshop on ozone issues in May of this year with the World Meteorological Organization. More than 110 scientists attended from countries all over the world, and a consensus report from that Workshop will be available later this year.

Countries do differ on the appropriate response to this data base. However, the extent of policy disagreement has been greatly exaggerated (see discussion below in ¶ B.l., p. 6). It is one thing to say governments disagree and quite another to say scientists disagree; the latter implies scientific controversy, while the former suggests only different priorities.

Allegation 2: The Environmental Protection Agency has proposed a production cap.

Response: EPA published an "Advance Notice of Proposed Rulemaking" seeking comments on the advisability and feasibility of regulation, as explained in NRDC's prepared testimony. EPA has not determined whether to propose regulation nor the method of regulation (although at the time of the ANPR a production cap was preferred).

Allegation 3: Restrictions on the availability of CFCs will injure small business.

Response: This issue is addressed in NRDC's submission to the House Small Business committee appended to these comments. In brief, we believe that the issue of small business impacts has yet to be fully evaluated but that EPA has clearly indicated it is aware of the potential problem. The RAND Corporation economic analysis specifically examined the impact of a production cap on small business and found that only isolated problems need occur. The report states: "neither collusion nor predatory behavior appear likely in the CFC permit market, neither would limit the emissions reducing potential of a permit policy, and both appear readily amenable to the same sorts of regulatory control that are currently available for other commodities and securities markets" (p. 245).Industry has, for the most part not attempted to suggest ways to modify the concept to correct the problem but has instead simply used it as an excuse for opposing regulation in any form.

In addition, because EPA has not proposed regulation, it is presumptuous to asume that regulation must occur in the form of a production cap. Regulation could be done through technology based controls, through a cap on new capacity, or any one of several means never discussed by industry.

Allegation 4: Restrictions on CFCs will have a high energy cost.

Response: Current use of CFCs in rigid foams and refrigeration insulation does provide substantial energy savings benefits. EPA has examined the issue through the RAND report. However, there are reasons to expect that the energy penalty of a CFC reduction may be overstated. First other insulating materials can be substituted for CFCs. RAND recognized this possibility but did not take it into account because the thicknesses that would actually be used "cannot be predicted with available information" (p. 114). However, building energy use is being increasingly regulated, and therefore if CFC insulation is unavailable it is reasonable to expect that other materials (such as fiberglas) will be used to achieve equivalent energy savings, although possibly at higher cost. In the case of refrigeration, RAND notes that equivalent insulation must be used to maintain desired temperatures but that, for purposes of worst case analysis this substitution was not assumed. If a federal mandate for appliance efficiency standards is implemented, substitute methods of achieving energy savings -- although again for some cost -- will be required.

It must also be recognized that there are other means of saving energy besides insulation. This is particularly true in the context of building energy consumption. Changes in window area and materials, thermal mass, heat recovery and the use of solar energy systems are only a few of the alternatives to insulation as a means of reducing energy consumption. Appliances can also be made more energy efficient through improved motors and compressors, heat recovery, greater use of microprocessors and design changes (such as the location of the freezer compartment and vegetable trays).

Finally, we note that the refrigeration industry, through its trade association, has expressed strong opposition to energy efficiency standards for appliances. The industry's commitment to promoting energy conservation -- as opposed to simply reducing costs -- is therefore somewhat questionable.

Allegation 5: Restrictions on CFCs will severely impact home air conditioning.

Response: As Senator Bentsen emphasized, home air conditioning is now an essential element of life in many parts of the country, particularly the Southwest. However, none of the witnesses noted that home air conditioning systems use a type of CFC which is not considered a threat to the ozone layer. As the RAND report states, "we have not treated CFC-22 as a principal ozone hazard, and home and supermarket air conditioning systems are not included in the list of analyzed products" (p. 3). The home air conditioning market is therefore not an issue. This point is discussed further in point B.3. of these comments (p. 8).

B. Responses to Supplemental Questions

1. "What have other countries done to regulate CFCs?

Response: This question is discussed in our testimony (p. 12) and in our comments on the ANPR (pp. 38-40). In addition, a draft report by the Organization for Economic Cooperation and Development (OECD), which includes all the major CFC producing nations, reviews the CFC policies of member governments. Since this report reflects the official position of each country and is current as of early this year, I have enclosed a copy of the relevant pages.

The European Community agreed to consider further action at a June meeting subsequent to preparation of the OECD draft. The EC policy is based on prevention and precaution. Member states were required to reduce aerosol propellant uses of CFCs by 30% of 1976 levels by the end of this year, and they will in fact exceed this target. (Aerosol uses have historically constituted a substantial fraction of total use in EC countries, so that this reduction is more significant than it was in the United States.) The EC countries also have a production capacity cap, a policy the EC supports for adoption worldwide. The EC will undertake projects with industry toward reducing emissions from refrigeration, foam blowing, and solvents. They intend to write a code of practice of industrial handling of CFCs and for equipment design in the refrigeration industry. The feasibility of CFC recovery for foam blowing is being studied, as is the nature of solvent uses of CFCs and possible alternatives.

The EC decisions and the actions described in the OECD report belie any conclusion that other countries are not concerned about ozone depletion. Rather, the facts suggest differences in regulatory approaches and perceptions of the economic imortance of CFCs in different national contexts. Other countries have been able to achieve substantial reductions in CFC use without regulation. Japan is the classic case; the government has decided to impose a cap on production capacity equivalent to the EC policy, but because of the close relationship between government and industry no formal regulation is necesary. (This tradition has been applied effectively to many environmental problems as described in a study of Japanese CFC policy prepared by Professor Julian Gresser for NRDC.)

2. "How good is ozone trend analysis at predicting ozone depletion?"

Response: Ozone trend analysis is not a method for "predicting" ozone depletion; unfortunately no such method exists. Rather, trend analysis is a statistical technique for verifying whether depletion due to man-made activitites has occurred. All sides agree that, as Dr. Greenwood of NASA testified, ". . . it is not [currently] possible to verify the trend analysis models nor to firmly establish limits on the level of estimated impact based solely on analyses of the limited historical data available." The controversy is limited to the likelihood that this situation will change dramatically in the near future, justifying additional delay in decisions on regulatory policy. We address this issue in response to question six.

3. "Do all CFCs have the same effects on ozone? Are all CFC products interchangeable? Can you use different CFCs to manufacture the same products?"

Response: The answers to these questions are provided in the ANPR and the supporting analysis by the RAND Corporation. As stated in the ANPR, "Ozone depletion potential is primarily a function of molecular chlorine content by weight and the lifetime in the atmosphere of the various CFC compounds" (45 Federal Register 66731, Oct. 7, 1980). CFC-115, for example, is only 20% as harmful to the ozone layer as an equivalent weight of CFC-11. Another CFC, CFC-22, is partially halogenated, and therefore has a shorter lifetime and relatively little reaches the stratosphere. CFC-22 is therefore generally not considered as ozone depleting as fully halogenated CFCs.

The RAND study describes in detail opportunities and obstacles for substituting less hazardous CFCs. The potential is clearly there. CFC-22 is already widely used in home and supermarket air conditioning, so that these uses demonstrate an alternative to more hazardous forms of CFCs. The problem is that substitution is not possible in existing equipment; modifications are necessary. It is very likely that, if CFC uses are decreased gradually, the necessary technology will be developed at a cost which industry can absorb. In contrast, if we wait until ozone depletion is detected, the cost of precipitous cutbacks will create enormous problems for the industry.

4. "What are the risks to the environment of switching to alternative CFCs for alternative coolants in the refrigeration and air conditioning industry?"

Response: The impact of alternatives to CFCs is an important and difficult question. Certainly some of the chemicals under consideratin have less desirable properties than CFCs. The risks depend on the substitute and its use. Policies can be devised to minimize the use of any substitute thought to be a serious hazard. From the standpoint of formulating regulatory policy, the meaningful questions are how to minimize the risks from alternatives and, having done so, to compare them with the risks of ozone depletion.

The first priority ought to be more efficient use of CFCs through recycling and measures that reduce emission losses. These policies are available for some applications as described in the RAND analysis. Recovery and recycle is most feasible for flexible and rigid foams, while equipment standards could reduce the use of CFCs for solvent applications.

Regulatory policy is also the best incentive for the development of new alternatives. Without some indication that regulation is likely, investors have little reason to support research on alternatives since CFCs are entirely satisfactory apart from their threat to the ozone layer. The problems are exemplified by the testimony given by the representative of the Rovac Corporation. One would expect that anyone claiming to offer a cheaper, energy efficient alternative to CFCs as a refrigerant would have industry knocking down his door. In fact, the company has found no interest among large corporations. Only the threat of regulation is likely to bring about a change. Similar attitudes were expressed concerning alternatives to CFCs in aerosols, but alternatives were found when regulations were adopted.

Ultimately, some trade-off must be made between the risk of ozone depletion and any risks from alternatives to CFCs. While judgments are inherently difficult, emphasis must be given to the qualitatively different nature of the risks. Ozone depletion will be inflicted upon future generations without their consent and will continue for decades. The damage is potentially catastrophic. In contrast, the risks of alternatives to CFCs are potentially serious but can be confined much more to situations in which the risks are voluntarily assumed and can be minimized by preventive actions. The risks are also far less likely to persist beyond the time of use. In such circumstances, the risks from CFCs arguably merit greater concern.

5. "Why is legislation necessary?"

Reponse: For the reasons suggested in our testimony and amplified in these additional comments, we believe legislation is not necessary. The existing legal framework is appropriate for addressing the issues and EPA has shown itself to be sensitive to industry concerns.

6. "If we switched the emphasis of research purely to verification of the ozone depletion theory, how long would it take to verify or invalidate the theory?

Response: As our prepared testimony indicates, the latest judgment by EPA, after involvement in the May WMO/NASA meeting and consultation with industry, is that detection is "unlikely" for "at least the next ten years" (Testimony, p. 6). This is identical to the conclusion reported in the most recent scientific update of the U.N. CCOL in late 1980, also with industry participation. The United Kingdom Pollution Paper, cited by industry for its differences with EPA, also downplays the likelihood of imminent breakthroughs in our ability to detect depletion. The underlying technical problems are discussed in our comments on the ANPR (pp. 7-11).

The basis problem is that many of the same uncertainties that exist concerning our ability to model the effects of chlorine molecules in the atmosphere also impair our evaluation of ozone trends. As our understanding of the complexities of the basic systems increases, the significance of trend analysis will also improve. Unfortunately, there is no scientific basis for expecting such improvements in knowledge will occur according to any predetermined timetable.

enclosures: OECD CFC Report (Draft), Chapters IV and V
Small Business Committee letter

Attachment 1

Submission of the Natural Resources
Defense Council to the House Small
Business Committee, July 27, 1981

Natural Resources Defense Council, Inc.

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27 July 1981

House Small Business Committee
Subcommittee on Antitrust
& Restraint of Trade
Activities Affecting
Small Business
Attn: Ty Marsh

Dear Mr. Marsh:

The enclosed statement on the impact of ozone protection policies on small business is submitted for inclusion in the hearing record of July 15th.

Sincerely,

Alan S. Miller

Statement of the NRDC Concerning the Impact of Policies to Protect the Ozone Layer on Small Business

On July 15, 1981, the Subcommittee on Antitrust and Restraint of Trade Activities Affecting Small Business of the House Committee on Small Business held a hearing on EPA's ozone protection policies and possible implications for small business. Because NRDC has worked for policies to protect the ozone layer for many years, and because certain misinformation and misleading statements were made by several witnesses, we are submitting this statement for the record.

NRDC's Efforts to Protect the Ozone Layer

The Natural Resources Defense Council is a national, non-profit conservation organization with more than 40,000 members in the U.S. and more than 20 other countries. NRDC recognizes the importance of global resources as well as domestic environmental problems, and for that reason we have worked for policies to protect the ozone layer for many years. We filed the initial petitions with the Food and Drug Administration and the Consumer Product Safety Commission which ultimately led to the ban on use of chlorofluorocarbons (CFCs) for aerosol sprays.

NRDC staff members serve on several relevant EPA Advisory Committees, on technical committees of the Organization for Economic Cooperation and Development (OECD), and on numerous professional bodies concerned with hazardous chemical control policies. NRDC's involvement in the CFC issue also reflects a commitment to help resolve the difficult, complex policy issues inherent in chemical regulatory policy. With the assistance of several outside experts, we prepared a twelve-country comparative study of fluorocarbon regulation funded by the German Government. Conclusions were presented at an international meeting of governments on the CFC problem held in Munich in December 1978. NRDC was the only nongovernmental organization invited to participate, and the study was subsequently published as a book.

The Importance of Policies to Protect the Ozone Layer

While for jurisdictional reasons the hearing focused solely on the issue of potential small business impacts from restrictions on the availability of CFCs, industry testimony gave the impression that regulation would serve no useful purpose. No one is for needless regulation; the issue is whether the costs are worth the benefits.

As is true of many environmental problems, the costs are far easier to quantify than the benefits. This is particularly true of the CFC issue. We think we know the qualitative risks--increased skin cancer and diminished marine and agricultural productivity due to damaging ultraviolet radiation, and climatic changes due to perturbations of the upper atmosphere. These risks are described in the 1979 NAS report, and the 1980 United Nations Environment Program report, and an update by the National Academy of Sciences. What we cannot do is quantify the risks. Nor will be able to do so until substantial injury will already have occurred. However, this does not make the threat any less real or less a matter for concern.

The Status of EPA's Consideration of Regulations to Protect the Ozone Layer

Several of the witnesses referred to EPA's "proposed regulations," implying that a proposed rule had been promulgated. This is simply untrue. EPA issued an "Advance Notice of Proposed Rulemaking" asking for comments on possible regulatory proposals. As the Notice stated, "EPA solicits comments on the appropriateness of restricting the use of CFCs and on the feasibility of implementing the Mandatory Controls and Economics Incentives Approaches". (45 Federal Register 66726, October 7, 1980)(emphasis added) This was a commendable effort to obtain industry and public comment in advance of an agency decision to regulate, much less a commitment to any specific form of regulation. Instead of receiving praise for seeking public comment, the Notice has been characterized incorrectly as a regulatory proposal and made the target of an industry onslaught unprecedented since the Allies invaded Normandy.

Many small businesses are clearly so terrified of the possibility of regulation that they do not care about the legal distinction between a proposed regulation and an advance notice of proposed rulemaking. Larger firms have no such excuse. The unfortunate result is likely to be a reluctance on the part of agencies to be so open in the future. The lesson is clear--working with industry doesn't mean industry will work with you. More fundamentally, issuance of an advance notice provides much less basis for Congressional action. Whereas industry contends their concerns have been unfairly treated at EPA, the truth is that the Agency has gone out of its way to listen to industry.

The Impact of Ozone Regulation on Small Business and the Economy

Every industry witness discussed only the consequences of a production cap, as if that was the only possible form of regulation. In fact, as the RAND Corporation studies and ANPR make clear, there are many alternatives under consideration. To note simply one example, the United States could adopt a ban on new production capacity similar to the policy adopted in the European Economic Community and recently in Japan. Technology based controls could also be adopted to require the use of alternatives and recycling measures on an industry by industry basis, much like in other areas of pollution control. EPA, as stated above, has absolutely no commitment to a production cap, and any more workable approach should and will be considered.

At the same time, industry witnesses were less than objective in their assessment of a production cap. They assumed the absolute worst possible scenario, including no effort to assure that small businesses would have fair access to the available supply. The results may be dramatic but they are not particularly relevant. The purpose of seeking industry comment is to allow modification of regulatory proposals to prevent undesirable consequences. Small business impacts are discussed in the RAND report and are being considered by EPA. If the industry was truly concerned about the plight of small business, it would propose means by which a production cap could be modified to address small business needs. However, rather than attempt to offer constructive criticism, industry chooses simply to condemn the concept in its entirety.

The irony of this situation is that a marketable permit approach was investigated and presented in the ANPR specifically for its economic benefits. The RAND study documents, on an industry by industry basis, the substantial savings achievable from the adoption of an economic incentives approach as opposed to more traditional forms of regulation. Again, rather than encourage and contribute to the evolution of a promising alternative to bans or technology based controls, industry has chosen obstructionist tactics.

Conclusion

Protection of the ozone layer raises important policy concerns. However, one sided discussion focused solely on the viewpoints of the affected industry does very little to advance public debate. Any future hearings should include representation of other points of view.

Attachment 2

"Report on Chlorofluorocarbons"
by the Environment Committee of the
Organization for Economic Cooperation and
Development
6 March 1981 Draft
Chapters IV and V

CHAPTER IV - APPROACHES BY OECD MEMBERS AND THE EUROPEAN COMMUNITIES

250. This chapter discusses the actions taken to date by OECD member countries and the EEC to regulate CFCs, and discusses possible and proposed further actions. It is based on submissions received from member countries, complemented by reference to reports prepared for the CEC by Metra Consulting Group of London (5,11) and a book by Thomas Stoel et al (12) funded by Germany's Umweltbundesamt (Federal Environmental Agency).

AUSTRALIA

251. Australia is a relatively small producer of CFCs, having manufactured about 12,000 tonnes (about 1% of the world total) in 1979. Imports are negligible. Approximately two-thirds of production is used in aerosols.

252. The aerosol industry in Australia has acted voluntarily to reduce the use of CFCs in aerosols, partly in response to community concern about the possible effect of CFCs on the earth's ozone layer. Between 1974, the year of peak usage, and 1979 the amount of CFCs used in aerosols was reduced by 35%. During the same period total production of CFCs declined about one quarter.

253. Australia maintains a program of atmospheric ozone monitoring at a number of sites and has participated in major international meetings on CFCs and the ozone layer. The status of CFC use in Australia and of scientific knowledge of the relationship between CFCs and the ozone layer is currently being reviewed by the Commonwealth and State Governments. It is expected that the review will be completed and policy recommendations formulated early in 1981.

BELGIUM

254. There is no CFC production in Belgium, but there exists a relatively important filling and can production industry, using over 50% of the total imports of CFCs. A legal base for limitation of CFC use in aerosols exists in the 1964 law on air pollution prevention. A regulation to reduce the use of CFCs in aerosols by at least 30% as compared to the 1976 level is being worked out by the Belgian authorities in cooperation with the industry.

CANADA

255. Canada has the authority to control toxic substances under the Environmental Contaminants Act of 1976. Canada is a relatively small producer of CFCs, about 2% (23,500 tons) of world production in 1974. In 1979, aerosol use only accounted for 20% of production. This is a reduction of approximately 79% from aerosol use in 1974 (the peak year for production of CFCs). This reduction was partly due to a voluntary agreement

ith the aerosol industry to reduce their 1974 consumption of FC by 50% by the end of 1977. Canada has been actively nvolved in the CFC issue and has taken part in the international meetings on the subject. On 3rd April 1980, final regulations concerning the use of CFCs in aerosols were published (6). This regulation, which became effective on 1st May 1980, prohibits the import, manufacture, processing, sale and use of any chlorofluorocarbon ($C_nCl_xF_{2n+2-x}$) in aerosol hair sprays, deodorants and antiperspirants.

DENMARK

256. Denmark is not a producer of CFCs, and in 1979 imported about 4400 tons of CFCs, of which less than 22% was used in aerosols. This is a reduction of nearly 50% from aerosol use in 1976 (from 1812 to 941 tons). This reduction has been obtained in cooperation with industry and as a result of the EEC Council Decision (2). Denmark is also developing a draft list of allowed propellants and solvents for use in aerosol cans in cooperation with industry.

FINLAND

257. Aerosol production, imports and sales can be regulated by the Aerosol Decision given by the Council of State according to the Act of Standardisation. The decision has not yet been used to reduce aerosol consumption. However, aerosol production and imports of CFCs in Finland has dropped steadily from the early 1970s until 1978, with a drop of about 20% in both in 1979. The Ministry of the Interior is studying the need to use the Aerosol Decision before the Act on Air Pollution Control comes into effect. The problem shall probably come to consideration when the Act comes into force.

FRANCE

258. France has the legislative authority to act on CFCs under the Chemicals Control Law of 1977 (7). Other acts, such as the Public Health Code (Code de la Sante Publique) and the Clean Air Law might also be interpreted to apply to fluorocarbons. France is a major producer of CFCs, with about 9% of world production in 1974 (72,000 tons), less than only the U.S. and Germany and about the same as the U.K., of which 38% was exported and 45% was used in aerosols. France has participated in the scientific and policy discussions concerning CFCs. No action is presently contemplated beyond the requirements of the EEC Council Decision (2) on CFCs.

GERMANY

259. Germany has the authority to regulate CFCs under the Federal Emissions Law (para 35) and under the new Chemicals Law (para 4(3)), which becomes effective on 1st January 1982. Germany is a major producer of CFCs with total production 88000 metric tons in 1974, about 11% of the world total. Of that total, about 53% went into aerosols and 31% was exported. At

this time, Germany has undertaken no regulatory action concerning CFCs, but has been seriously considering the issue for some time. Since shortly after the publication of the theory by M.J. Molina and S.J. Rowland (10), the German government and industry have been involved in research on alternative propellants and on the basic science involved in the theory. In 1977, the industry agreed to reduce aerosol use by one third by the end of 1979 using 1975 as a base. Reports from the aerosol industry indicate that that goal has been reached (from 50820 tonnes in 1976 to 32540 tonnes in 1979, or 36%), and that by the end of 1980, the reduction was about 40%.

260. The German Government has concluded that warning labels are not "opportune" at the moment, but that positive labels signifying that the CFC free product are significantly less harmful to the environment than comparable products may be possible. Germany is also a member of the EEC and subject to the Council Decision (2) on CFCs. As noted, Germany has already achieved the required level of reduction.

261. With regard to future actions, the German submission stated that due to the global effects of ozone depletion supranational and possibly worldwide actions are considered to meet the problem best and that the Federal Republic of Germany therefore strongly supports all efforts of supranational and international bodies and organisations: to cut down CFC emissions, with a reduction of the CFC use in aerosols as an important first step; to undertake further research to clarify the scientific background and to develop suitable substitutes and alternative techniques and or products; and to establish further investigations with the aim to meet possible social and economic impacts of regulations.

ITALY

262. Italy produced about 38,000 tons, or 5% of total world production in 1974. In that same year, imports exceeded exports by 7000 tons. Of the total domestic use, aerosols constituted about 70% of the total. Italy has no plans at the present to regulate CFCs apart from the EEC Decision (2). There is no legislation presently providing general control of toxic substances

263. The Italian submission noted "that the EEC members follow a common line in spite of the fact that some positions do not converge and different philosophies are used to handle the CFCs problem itself. As a consequence, the Italian position concerning "National Approaches" finds its natural place in the EEC policy". Italy is also presently and will continue to carry on research connected with the possibility of stratospheric ozone depletion by halocarbons, under the sponsorship of Government and Industry, in fields such as ozone monitoring, stratospheric constituent measurement, methods for measurement of atmospheric halocarbon concentrations, modelling and malignant melanoma epidemiology.

JAPAN

264. Japan presently does not have sufficient regulatory authority to regulate the use of CFCs.

265. Japan produced about 9% of the total world production of CFCs, or 81,906 tonnes in 1979, and use in aerosols accounted for about 14% of production. This is a reduction of about 25% from aerosol use in 1973. This reduction has been a result of the voluntary industrial efforts. The Japanese Authorities have stated in their submission that this has been achieved under difficult conditions.

266. Firstly, Japanese per capita aerosol consumption remains as low as a quarter of that of other advanced nations. Secondly, the Japanese High Pressure Gas Control Act, which was passed in response to a number of incidents in Japan, bans the use of flammable propellants in personal care aerosol products. Thus, under present law, the major alternative to CFCs in the U.S. and Europe may not be applicable in Japan.

267. The Japanese submission states that despite these difficulties, taking into account that the issue is a worldwide problem, Japan is in a position to take concrete further precautionary measures as follows:

1. Japan will continue to make efforts towards the rational and scientific understanding of the effect of CFCs on the ozone layer.

2. Japan is actively involved in various kinds of research and development efforts to find substitute products for CFCs, as well as other efforts for achieving further reduction of the use of CFC-11 and CFC-12 in aerosols. At the same time, Japan will continue to make efforts to collect both domestic and international information regarding related activities, with full attention on the safety or the products involved.

3. The Japanese Government will endeavour not to increase the production capacities of CFC-11 and CFC-12 for the time being.

NETHERLANDS

268. The Netherlands has the authority to control air pollution, which is very broadly defined, through the Air Pollution Act of 1970. In 1974, the Netherlands accounted for about 4% of world production (29,000 tonnes), of which just over half (15,000 tonnes) was exported. Aerosols accounted for approximately 75% of domestic use.

269. The Netherlands is the only EEC country to have adopted regulations concerning CFCs. A royal decree requiring a warning label was published on 30th October 1978 and became effective on 1st April 1979. The label reads: "Warning: contains chlorofluoromethanes that may be damaging to the environment and to human health by decreasing the ozone in the stratosphere".

270. According to the submission by the Dutch government, the use of CFCs in aerosols has already been reduced by 30% compared to 1976. The warning label probably contributed noticeably to this decrease. Further, the Netherlands has made an agreement with its aerosol industry to reduce use of CFCs in aerosols by another 20% by 31st December 1981. The producers of CFC-11 and CFC-12 also agreed not to increase their production capacity. Although a reduction of 50% on a voluntary basis is considered valuable, in principle, such a regulation should finally be laid down in regulations. Within the Dutch Government, the possibilities for such a regulation are at present under consideration.

271. The decree also provides that if new scientific evidence should confirm the 1976 data and other major producing nations take action, a ban on the use of CFCs in aerosols will follow. The Netherlands considers that the first condition is fulfilled and that the Decision of the Council of the European Communities is a first step towards fulfilling the second. The high alcohol duty is a hindrance to the development of CFC-free aerosols, and the Dutch government is working to solve that problem.

272. The Netherlands government is also concerned about non-aerosol uses. The different uses (refrigeration, rigid and flexible foam manufacture, and air-conditioning) each require a different approach. The relevant policies have to be discussed within the government and with the industries.

NEW ZEALAND

273. Regulations to control or ban the importation of CFCs (there is no domestic manufacture) could be introduced under the Toxic Substances Act of 1979. The Act could also be used to prohibit, restrict or regulate the sales distribution, storage custody, handling or use of the material.

274. In 1975, at the request of the Minister of the Environment, the New Zealand industry was approached to suggest that it should be considering contingency planning and reducing the use of CFCs. Surveys of use were made and information on the economic effects of restrictions was sought. In March 1979 the government asked the Royal Society to investigate the current evidence and the likely consequences to New Zealand of continued CFC use. The report was released in November 1979, and it endorsed the predicted effect of continued release of CFCs on the atmosphere and stated that, despite the uncertainties, the predicted effect is large enough to be of concern. The Committee, nevertheless, did not consider that a ban on CFCs at this time would be justified. Rather, the Committee stated that it would be sensible to encourage manufacturers to decrease CFC usage and adopt alternatives.

275. New Zealand is a small user of CFCs, less than 1500 tonnes in 1979, of which 26.4% went into air conditioning and refrigeration. The use of CFCs in aerosols has decreased from 1367 tonnes in 1974 to 693 tonnes in 1979 (with 610 estimated for 1980). Total use has decreased from 2119 to 1487 tonnes over the same period.

NORWAY

276. Norway has the authority to regulate CFCs and has in fact utilised this authority. In 1977, Norway, which is not a producer of CFCs, imported and used about 2,100 tonnes, or 0.2% of world use. In their regulation, Norway has prohibited the manufacture or import of aerosol cans containing CFC propellants. The regulation exempts medical products and allows further exemptions after a decision by the State Pollution Control Authority and subject to such conditions as are considered necessary.

277. While no mention has been made of specific future actions, the Norwegian authorities stated recently that they "are trying to bring about the introduction of international measures to control the use of CFCs." In this regard, a meeting on the international regulation of CFC emissions convened by the the Norwegian Authorities was held in Norway in April 1980, which elaborated a series of principles relating to CFCs and their control. A number of OECD member states attended this seminar.

SWEDEN

278. Sweden has the authority to control CFCs under the Act on Products Hazardous to Health and the Environment (1973:329) and under the more detailed Ordinance on Products Hazardous to Health and the Environment (1973:339). Sweden is not a producer of CFCs, and imports in 1974 amounted to only 5,600 tonnes, of which 60% was used in aerosols.

279. Sweden has banned the use of CFCs in aerosol propellants except for medical products and other cases where exemptions are granted. This was done by means of an amendment to Section 48 of the Ordinance on Products Hazardous to Health and the Environment issued on 15th December 1977. The ban took effect on 30th June 1979.

280. While no further action has been specifically proposed at this time, the government has commissioned the Products Control Board to follow the developments in the use of CFCs, and to present proposals for further actions to limit their use. The Board is to specifically study non-propellant uses of CFCs in other countries.

SWITZERLAND

281. Switzerland presently does not have sufficient regulatory authority to regulate the use of CFCs. However, the Parliament has been considering since the Autumn of 1979 a law on the protection of the environment. If this law is accepted, the authority to regulate CFCs will exist, and in this case, if the situation regarding potential ozone depletion by CFCs does not change significantly, Swiss authorities anticipate prohibiting the use of CFCs in aerosols with exceptions.

282. Swiss authorities are presently in contact with industry about voluntary reductions, and the use of CFCs in aerosols has declined 23% between 1977 and 1979. Over the same period, production of aerosols has dropped only 5%, but CFC have dropped from 83vol% of the total propellant use to 63vol%. Aerosols are estimated to account for about 90% of the use of CFCs in Switzerland. Authorised substitutes for CFCs include propane, butane and dimethyl ether. Use of methylene chloride and 1,1,1,-trichloroethane is not authorised in cosmetics.

UNITED KINGDOM

283. The U.K. has adequate regulatory authority to control the use of CFCs under the Control of Pollution Act, passed in 1974. Section 100 authorises the Secretary of State for the Environment to issue regulations whenever he considers it appropriate to do so for the purpose of preventing a substance from causing damage to persons, animals or plants, or pollution of air, water or land. The government stresses the need to fully evaluate costs and benefits before acting, in order to minimise short-term economic disruption.

284. In 1974, the U.K. accounted for about 10% of OECD production (72,000 tonnes), with exports accounting for one third of that amount. Aerosols accounted for over 80% of that total.

285. In 1976 the Department of the Environment issued a report (8) which reviewed the stratospheric ozone problem and concluded that no precipitate action was needed at that time but further research was required to reduce the uncertainties in future decision-making. At the same time, manufacturers of aerosols and plastic foams using CFCs were recommended to intensify their search for alternatives and similarly manufacturers and users of industrial equipment using CFCs should seek to minimise leakage of the materials during operation or maintenance of the equipment.

286. Much research on the problem has been carried out in the U.K. since that time and in 1979 a further major assessment of the problem was published by the Department of the Environment (9) which included a detailed scientific evaluation carried out by the Stratospheric Research Advisory Committee. The report concluded that the problem is of global concern, and advocated precautionary measures but that, rather than develop domestic policies, it was more logical to seek such policies within the

framework of the EEC. Subsequently the U.K. supported the EEC decision and has reached agreement with industry to ensure compliance with it. The authorities are actively involved in research on ozone depletion, which includes pioneering development of two-dimensional models and participate actively in discussions at the international level. The U.K. prompted the EEC into sponsorship of the resolution adopted by UNEP on 29th April 1980. A further review of the situation is expected in 1981.

UNITED STATES

287. The United States has the authority to control the use of CFCs under several Acts, including the Federal Food, Drug, and Cosmetics Act, the Consumer Product Safety Act, the Federal Insectide, Fungicide, and Rodenticide Act, the Clean Air Act, and the Toxic Substances Control Act (TSCA). None of these acts enables the complete control of CFCs, but, in total, they cover every possible use. The Clean Air Act as amended in 1977 requires EPA to undertake research on the effects of halocarbons on stratospheric ozone and perform any other research as may be necessary to determine the effects on human health or welfare of changes in the stratosphere. The Act also requires research cooperation between the Environmental Protection Agency and research by other federal agencies, such as the National Oceanographic and Atmospheric Administration, the National Aeronautics and Space Administration, the National Science Foundation, the Department of Agriculture, and the Department of Health and Human Services e.g. the National Cancer Institute. Further, the Administrator is required to promulgate regulations, if in his judgement, any activity may reasonably be anticipated to endanger the public health or welfare.

288. The U.S. is the world's largest producer and user of CFCs. In 1974, the U.S. produced over half of all OECD production, of which about 60% (224,000 out of 376,000 tonnes) went into aerosols. The U.S. has regulated use of CFCs as aerosol propellants, forbidding their use except with special exemptions. Reporting by manufacturers and users of CFCs indicate that use of CFCs in aerosols in the United States has been reduced by over 95% from 1974 to approximately 5,500 tonnes. Due to the aerosol ban, the U.S. produced only 40% of the world's production in 1979.

289. In early October, 1980, the EPA published an Advanced Notice of Proposed Rulemaking on CFCs, which is an early announcement of possible regulatory options, and which solicits comments from interested parties. The Advanced Notice outlines several possible regulatory alternatives ranging from no action at all to cutbacks in CFC use. It recommends an intermediate "no-growth" strategy which would be precautionary and would attempt to spur technological innovation in the development of substitutes and methods of recovery and recycling. The

currently preferred option for accomplishing this is a marketable permits system which would restrict production of all CFCs such that the total potential for depleting ozone would not increase over present levels. The procedure is that an Advanced Notice is followed by a proposed rule, further review, and then a final rule, if evaluation of public comments, scientific studies and economic analysis warrants.

THE EUROPEAN COMMUNITIES

290. On 30th May 1978, the Council of the European Communities adopted a resolution (1) calling for measures to encourage industry to intensify research into and promote development of alternative products and methods of application, as well as to eliminate the discharge of CFC-11 and CFC-12 from equipment containing them, and stated that all appropriate measures should be taken to ensure that the industry within the Community did not increase its CFC production capacity. A further review of the impact of CFC on the environment was provided for.

291. In accordance with the terms of the resolution, and based on the results of the international conference held in Munich in December 1978, the EEC Council agreed, on 17th December, 1979, on a Decision (formally adopted 26th March, 1980) (2). The Decision states that EEC Member States shall take measures to ensure that their industries do not increase production capacity for CFC-11 and CFC-12 and shall achieve, not later than 31st December, 1981, a reduction of at least 30% in the use of these CFCs in aerosols compared with 1976 levels. Furthermore, in the first half of 1980 a reexamination of scientific and economic data was announced. Not later than 30th June, 1981, the Council shall adopt such further measures as may be necessary in the light of that reexamination.

292. For the purpose of that reexemination, the Commission of the European Communites made an evaluation which was presented to the Council of Ministers on 30th June 1980 (3). Two reports were annexed to this communication: the first one by Guy Brasseur gives in the field of scientific data an "Analysis of recent reports on the effect of chlorofluorocarbons on atmospheric ozone" (4). The other is the second Metra report (5). In 1979 CFC usage in aerosols was 136,552 tonnes and shows a total fall of 40,362 tonnes compared to the 1976 level, or 22.8%.

OTHER NATIONS

293. Little or no information is available at this time concerning the present or planned activities of the other members of the OECD concerning CFCs, although the members of the EEC are required to comply with the Council Decision.

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11. Metra Consulting Group Ltd. Social and Economic Implications of Controlling the Use of Chlorofluorocarbons in the EEC, London (October 1978).
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CHAPTER V INTERNATIONAL ACTIONS

A. CURRENT ACTIVITIES OF INTERNATIONAL ORGANISATIONS

1. OECD (Studies, Reports, Plans)

294. At the 16th Session of the OECD Environment Committee (12th-14th November, 1975) a review of the potential problems was presented by the Canadian and United States Delegations. The Committee agreed on a study to be made on the consequences of restrictions on the use of CFCs, under the lead responsibility of the Chemicals Group. Member countries were invited to supply information. Subsequently a work programme was prepared.

295. The United States/Canadian review was derestricted as a first interim report (1) and the work programme was approved by the Environment Committee at its 17th Session (16th-18th March, 1976).

296. The Final Report of the study was completed 23rd January, 1978 (2) and it included:

- data on CFC production and consumption
- a discussion of possible regulatory measures
- a discussion of the economic, technological and social impact of regulating the use of CFC-11 and CFC-12
- listings of the relevant activities of other international organisations
- listing of possible substitute propellants.

297. It was decided that an inventory of research in the field of stratospheric dynamics and biological and non-biological effects of UV was more appropirate for the United Nations Environment Programme to compile.

2. United Nations Environment Programme (UNEP)

2.1 General

298. In response to a Governing Council request UNEP convened a meeting of experts on the ozone layer in Washington (1st-9th March, 1977). A world plan of action on the ozone layer was adopted. The Governing Council approved of this approach on 25th May, 1977. UNEP recognised the threat to the ozone layer as one of the important global environmental problems (3), and has been playing a major part in evaluating the chlorofluorocarbon issue. To co-ordinate the implementation of the action plan and to evaluate research related to the ozone layer, the Co-ordinating Committee on the Ozone Layer (CCOL)

was formed from representatives of organisations and countries which have major scientific programmes contributing to the action plan. The co-ordinating role of UNEP in research on the ozone layer and the role of UNEP in the assessment of the results of research on the ozone layer is recognised both by the OECD and EEC.

7.2 CCOL (Assessments and Recommendations)

299. Since its inception CCOL has met once each year. At the first meeting in Geneva (1st-3rd November, 1977) (4) it was agreed to prepare a bulletin summarising information on ongoing and planned programmes, on relevant publications and addresses of scientists and institutions. The first edition of the Ozone Layer Bulletin was issued in January 1978 (5). The Bulletin is now published annually.

300. At the second meeting held in Bonn (28th November-1st December, 1978) (6) an assessment of ozone depletion and its impact was worked out. According to that assessment, the atmospheric research programmes have led to reasonably consistent model predictions of ozone depletion, even though there are large uncertainties in the assumptions underlying these estimates. Other uncertainties are due to natural variations and trends in stratospheric ozone concentrations that are neither well recorded nor well understood at present.

301. As far as the impact of CFCs on the ozone layer is concerned, the conclusion of the assessment was that according to current model calculations a 2% depletion must have occurred already. If release of CFMs were to continue indefinitely at the 1977 rate, a steady-state depletion of 15% was predicted. These are central values of model calculations which involve uncertainties of the same order as the values themselves. The CCOL pointed out the conclusions of the World Meterorological Organization that the threat to the ozone layer is very real and warranted continued action to control the quantity of CFMs released into the atmosphere, and recommended policy makers consider the findings and take such actions as may be deemed appropriate at that time. A comprehensive environmental assessment of the impact of ozone depletion, including the economic aspects of corrective and alternative actions was recommended. National and international bodies were encouraged to continue to promote vigourous monitoring and research efforts in order to achieve understanding of this complex problem on a reasonable time scale.

302. A second assessment was made at the third CCOL meeting in Paris (20th-23rd November, 1979) (7). The conclusions were broadly similar to those reached in 1978. The CCOL was of the opinion that the conclusion concerning the ozone depletion was still valid and was supported by the state of scientific knowledge in 1979.

303. It was concluded that in some areas (e.g. kinetics, effects, etc.) some of the uncertainties (e.g. the consistency of ClO measurements with model predictions) had been reduced. The effects of CFMs on climate were predicted to be less significant than their effects on stratospheric ozone.

304. The Committee welcomed the agreement reached by the governments at the International Conference on CFMs in Munich to reduce CFM emissions significantly. Governments were encouraged to undertake all efforts to reach as large a reduction as possible. The Committee requested CFC-11 and CFC-12 producting companies to provide annual production figures to the national governments as agreed in Munich and proposed to include other relevant components (e.g. CH_3CCl_3). Detailed recommendations for further studies were given.

305. A third assessment was made at the CCOL's fourth session held in Bilthoven, Netherlands (11th-14th November, 1980) (9)*. Because of revisions in certain reaction rate coefficients, it was concluded that the models' current predictions reduced the globally averaged ozone depletion due to the continued emissions at 1977 levels of CFC-11 and CFC-12 alone to about 10%. Depletion to date due to these two chemicals is predicted to be about 1%. The Committee also noted that 2-D models, carrying out more realistic calculations, predicted significant variations in ozone depletion with latitude and season which should be taken into account when evaluating the health and environmental effects of ozone depletion.

306. It was concluded that no evidence of change in ozone attributable to human activities had been observed to date, but that the 1% change predicted to have already occurred could not be measured directly with present technology.

307. The Committee recognised that long-term trend detection was a difficult task and recommended that satellite monitoring should be integrated with a well-kept ground based monitoring system through a Global Ozone Observing System (GOOS).

308. It was broadly agreed that an increase in solar UV radiation would lead to an increased incidence of non-melanoma skin cancer in light-skinned people. It was also concluded

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* Included at the fourth session:

Governments: Denmark, France, F. R. of Germany, Italy, Japan, Netherlands, Norway, Sweden, U.S.S.R., U.K., U.S.A.
U.N. Agencies and Specialised Agencies: W.H.O., W.M.O., U.N.E.P.
Intergovernmental Organisations: E.E.C., O.E.C.D.
Non-governmental Organisations: I.C.S.U., C.M.A.

that, while recent research results indicated that many terrestrial plants, including crops, and many aquatic species might also undergo damage by increased UV-B, further investigation were needed to establish the overall ecological effects.

309. The Committee recognised that while there has been a decrease in world production of CFC-11 and CFC-12 since 1974, mainly caused by a reduction in aerosol use, this could be offset in a few years' time by continued growth in non-aerosol uses of these two chemicals. The Committee also noted that there were indications of icreased production of other chlorine-containing compounds which could affect the ozone layer, and these would require increased consideration.

310. Overall, the Committee felt that a risk of depletion of the ozone layer due to CFC releases was still most likely. The Committee emphasised the importance of continued co-ordinated studies on the ozone depletion problem between Member countries and international orgnanisations.

311. The complete 1978, 1979 and 1980 assessments and recommendations are added as Appendices D-1 to D-3.

2.3 Resolution

312. In its 12th Meeting (29th April, 1980) the Governing Council adopted a resolution regarding CFCs. It recommends that governments, especially those of countries where use of the CFC-11 and CFC-12 is high, should achieve significant reduction in use, that production capacity for those CFCs should not be increased and that the measures already taken be re-examined in the light of scientific, technical and economic data available. Further scientific research and the development of substitutes is to be encouraged.

3. Council of Europe

313. On 3rd July 1980, a resolution on CFCs was adopted by the standing committee of the Parliamentary Assembly of the Council of Europe. The resolution was based on data collected in 1978 and the findings of the Munich Conference. It invites governments of member states to implement the decisions taken in the European Communities as expressed in the EC resolution of 30th May 1978 and the decision of 17th December 1979 (see chapter IV), and to improve the information of consumers by requiring labels indicating use of CFCs on spray cans. Finally, governments are invited to promote further research.

4. Other International Organisations

4.1 World Health Organization (WHO)

314. The World Health Organisation and UNEP are cooperating on an epidemiological study on skin cancer and ultraviolet radiation.

4.2 World Meteorological Organization (WMO)

315. The WMO is working on increasing the network of ozone monitoring stations and recently organised an intercomparison of European based Dobson Spectrophotometers. WMO also organised an international rocket-borne ozone-sonde comparison at Wallops Island in November 1979, which showed the need for continuous rocket measurements mainly for use in satellite data reduction. Other work includes an assessment of performance characteristics of ozone observing systems.

4.3 International Council of Scientific Unions (ICSU)

316. Work relevant to the ozone depletion problem is ongoing in several areas. These include:

1. studies of trace constituents in the atmosphere by the International Association of Meteorology and Atmospheric Physics,
2. a study of the global nitrogen cycle (including release of nitrogen oxides into the atmosphere) by the Scientific Committee on Solar and Terrestrial Physics,
3. work on stratospheric ozone reactions by the Committee on Data for Science and Technology and in particular by its Committee on Chemical Kinetics and,
4. symposium, data dissemination and programme coordination on photobiological research by the International Union of Biological Sciences and the International Association of Photobiology.

5. Chemical Industry Associations

317. The Fluorocarbon Project Panel (FPP) of the Chemical Manufacturers Association represents nineteen companies (from 9 countries) that represent almost all world production of chlorofluorocarbons. The FPP was founded in 1972, before the ozone depletion theory was presented, to look at the eventual fate and environmental effects of fluorocarbons, which at that time were being released to the atmosphere at a rate of nearly 450 million kilogrammes per year. Since 1975, the FPP has concentrated on the ozone issue and has funded over $8 million in research, with additional 1980 committments of between $1 million and $2 million.

318. Research sponsored by the FPP has included all of the major areas of research except measurement of ozone, which the Panel concluded could more effectively be accomplished by governments and international organisations. The current FPP research program includes :

- modelling,
- statistical time series analysis,
- laboratory measurement of reaction rates for those reactions for which rates are not well established (involving Cl, ClO, higher chlorine oxides and HO_2),
- studies on the tropospheric lifetime of CFCs, and
- simultaneous measurements of several key reactants by in situ and ground based methods.

319. Other chemical industry associations have also been actively involved in the chloroflurocarbon debate and have sponsored work in these areas. The European Fluorocarbon Technical Committee (EFCTC), which groups together the European CFC manufacturers, is carrying out toxicological testing of CFC-11, CFC-12 and HCFC-22. The Japanese Fluorocarbon Association is participating to this project. Tests of HCFC-22 with regard to lifetime inhalation, lethal dose and cytogenicity, are being carried out.

B. CONFERENCES

320. Under the auspices of the United States Government a conference of representatives of countries that are major producers and users of CFCs was held in Washington (26th-28th April, 1977) to review ongoing or planned regulation and to discuss the possibility of concerted international action.* It was agreed that co-operation in scientific research and exchange of information on scientific, economic, social and legal issues was necessary. Plans for national regulatory measures were presented. Several countries indicated their intention to regulate. It was agreed that a reduction of CFC emissions should be encouraged.

321. The Washington Conference was followed by a conference in Munich (6th-8th December, 1978) (8)** The Conference made recommendations on three topics:

(i) the problem of ozone depletion and associated hazards;

(ii) economic questions and analysis of economic consequences involving questions of trade;

(iii) alternatives for political decisions.

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* The Conference was attended by: Australia, Canada, France, F.R. of Germany, Italy, Japan, the Netherlands, Norway, Sweden, Switzerland, Union of Soviet Socialist Republics, the United Kingdom, the United States, EEC, OECD, WHO, WMO and UNEP.

** The Munich Conference was attended by: Australia, Belgium, Canada, Denmark, France, F.R. of Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom,

322. Under topic (i), it was recommended that full use should be made of existing scientific information, the coordinating role of UNEP in the area of scientific research on the ozone layer was reaffirmed and mention was further made of the areas where the scientific community recommended further research. It was recommended under topic (ii) that further studies of the technical and economic aspects of the CFC question, be undertaken, and that these studies should include an evaluation of substitutes. It was also recommended that annual production and use figures for CFC-11 and CFC-12 be provided on a national scale. Finally, under topic (iii), the conference recommended that as a precautionary measure there should be a global reduction in the release of CFCs and called on all Governments, industry and other bodies to work towards the goal of achieving a significant reduction in the release of CFCs over the next few years. The full text is included as Appendix D-3.

323. A third meeting on the international regulation of emissions of CFCs was held in Oslo (14th-15th April, 1980). The meeting was attended by representatiaves of Canada, Denmark, Germany, the Netherlands, Norway, Sweden, the United States and the Commission of the E.C. The agreed conclusion of the meeting was that the most likely ozone depletion, based on constant 1977 release rates, will be, on the average, 13-16%. The urgent need to take adequate steps to reduce the worldwide emission of CFCs was emphasised and the prohibition of the use of CFC in spray cans by four of the governments and the reduction of that use by at least 30% in the EEC was mentioned, as were the ceilings put on the production capacity of CFC-11 and CFC-12 by the EEC and the intended limit on production of CFCs in the United States. The danger of a shift of CFC production and use to countries presently not producing CFCs and within the different fields of application was recognised. Consideration of the CFC problem by the OECD Environment Committee was seen as an important step in the development of effective measures to protect the ozone layer. It was considered that a rational objective in the development of international co-operation in this area might be the negotiation of an international convention for the protection of the ozone layer. The full conclusions are contained in Appendix D-4 to this chapter.

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STATEMENT
of
ALLIANCE FOR RESPONSIBLE CFC POLICY

INTRODUCTION

The Alliance for Responsible CFC Policy is a broad-based coalition of about 500 users and producers of chlorofluorocarbons. It was formed in the summer of 1980 after EPA announced that it planned to limit the production of CFCs to current levels, and then eventually to cut production back by as much as 70 percent. Members of the Alliance range in size from large, well-known industrial enterprises with tens of thousands of employees to small, local businesses with few employees and limited resources.

One of the primary purposes of the Alliance is to cooperate with and assist governmental bodies to ensure that their directives and policies pertaining to CFCs are reasonable, scientifically sound, and economically and socially effective. In this connection the Alliance filed extensive comments on behalf of its members in response to EPA's proposals. In addition, although the Alliance does not itself undertake or sponsor scientific research, it does support the efforts of other industry groups which are engaged in extensive research with respect to all aspects of the ozone depletion theory discussed below. In that regard, all CFC producer members of the Alliance have, since the early 1970s, financially supported the efforts of the Fluorocarbon Program Panel of the Chemical Manufacturers Association.

Chlorofluorocarbons

Chlorofluorocarbons, or CFCs, are a family of chemical compounds containing carbon, fluorine, and chlorine. They were invented in 1928 as a replacement for the more hazardous and flammable chemicals then used for refrigeration. Since then, their nonflammabilty, low toxicity, and excellent heat-transfer properties have resulted in their use in a wide variety of other applications. Today they are also used in many applications because of their energy efficiency.

Numbers are assigned to the different CFC compounds to distinguish their molecular structures. Although other CFCs have commercial application, four of them - CFC-11, CFC-12, CFC-22, and CFC-113 - make up about 95 percent of domestic production and will be the ones we discuss here.

Ozone Depletion Theory

Controversy over CFCs began in 1974 when two scientists at the University of California advanced the "ozone depletion theory." This theory postulates that CFCs released at ground level eventually make their way intact into the stratosphere where they become involved in a complex series of chemical reactions which ultimately result in partial destruction of stratospheric ozone.

Since ozone absorbs part of the sun's ultraviolet rays, the more ozone in the stratosphere, the less ultraviolet light will reach the earth's surface. Less ozone, on the other hand, means more ultraviolet light. If CFCs do in fact break down ozone in the stratosphere, and there are no offsetting reactions, then more ultraviolet light will reach the earth's surface. The theory further postulates that the resulting increase in ultraviolet light at the earth's surface will have adverse health and environmental effects.

Publication of this hypothesis prompted worldwide research into the subject. Early assessments by the National Academy of Sciences (NAS), the National Aeronautics and Space Administration (NASA), and other bodies agreed that while there might be a problem, the science was highly uncertain. Then, in November and December 1979, the National Academy of Sciences issued reports which concluded that if CFC emissions continued at 1977 rates, there was a high probability that in approximately 100 years there would be a 16.5 percent depletion of stratospheric ozone.

However, on the basis of essentially the same evidence which was before the National Academy of Sciences panels, the United Kingdom, Department of the Environment (October 1979) and the Commission of the European Economic Community (June 1980) concluded that the science was so uncertain that further regulation of CFCs could not be justified at this time. While findings of the National Academy of Sciences command respect, EPA seems to have accepted these 1979 reports as conclusive, while they certainly are not, and ignored conflicting assessments. Moreover, scientific assessments have changed considerably since the NAS reports were issued, as we shall elaborate below.

EPA's Regulatory Proposal

On April 15, 1980, at an international conference held in Oslo, Norway, the then-Deputy Administrator of EPA, Barbara Blum, announced that EPA intended to put an initial cap on United States CFC production, and over time to reduce U.S. production by up to 70%. EPA's press release on the conference said without qualification that CFCs "can destroy the stratospheric ozone layer" and had the headline, "EPA To Tighten U.S. Control on Ozone-Destroying Fluorocarbons."

An Advance Notice of Proposed Rulemaking followed on October 7, 1980. Its first premise was that U.S. CFC production had to be capped immediately. The Alliance responded with extensive comments on January 5, 1981. EPA was preparing to issue a Notice of Proposed Rulemaking when the Carter Administration left office.

The Need for Legislation

EPA's proposal was inappropriate for a number of reasons.

First, there is not a scientific justification for EPA's proposed regulation of CFCs. There remains great uncertainty about the validity of the scientific theory on which EPA's regulatory proposal is based, and there is little risk in waiting for further scientific analysis to determine whether any further regulation of CFCs is required.

Second, regulation of production of CFCs would have an enormous adverse impact on our economy, which there would be no reason to endure in the absence of immediate risk.

Third, unilateral regulation of CFCs by the United States would be environmentally ineffective and, in the absence of evidence of immediate risk, would impose a pointless penalty on the American people.

For these reasons, the Alliance has opposed EPA's proposal for immediate regulation and supports instead the very prudent and constructive alternative policy embodied in S.517.

S.517 would postpone regulation of CFCs

> "until such time as an international agreement or agreements . . . are reached as to the nature, extent and implications of any threat to the concentration of ozone in the stratosphere and as to the appropriate regulatory action to be taken . . . to provide protection against the depletion of ozone in the stratosphere, or until depletion of the stratospheric ozone by chlorofluorocarbons at a rate determined to be eventually harmful to human health and the environment is actually detected."

We urge the Committee to act favorably on S.517, even through it remains to be seen what the new EPA

Administrator will propose with respect to CFCs. CFCs are so important to our economy, and contribute so much to our present standard of living, that it would be intolerable to leave their regulation to the unconstrained discretion of even the best-intentioned EPA Administrator, absent more specific statutory guidelines concerning the standards which should govern the Administrator. For reasons which will be explained, the public at large, as well as CFC users and producers, deserve assurance that the availability of CFCs will not be curtailed unless there is actual indication of stratospheric ozone depletion at a rate deemed to be harmful to health or the environment, or until there is international agreement on the science and on an effective control program. Only Congressional action will give that assurance. The Alliance submits, therefore, that enactment of S.517 is necessary regardless of the policy preferences of the current EPA Administrator.

Scientific Uncertainties

The scientific issues are not as settled as EPA has indicated. In fact, there remain numerous uncertainties in the ozone depletion theory, including the following:

First, do all CFCs released at ground level in fact travel into the stratosphere without other reactions occurring en route?

Second, do CFCs which reach the stratosphere become involved in fact in ozone-depleting chemical reactions?

Third, do the computer models of the atmosphere, which are used to calculate potential future ozone depletion numbers, accurately and thoroughly simulate the present atmosphere and further, how reliable are they for predicting future changes?

Fourth, if CFCs do reach the stratosphere in substantial quantities and do reduce the stratosphere's ozone content, how much ultraviolet light will reach the earth's surface and how much harm will it do?

And finally, and central to the entire issue, to what extent should one rely on the calculations of necessarily imperfect computer models over actual measurements of the atmosphere.

Extensive government and industry efforts to resolve these uncertainties are underway and will continue. The bulk of industry-sponsored research on the ozone depletion theory is funded by a group called the Flurocarbon Program Panel (FPP). The FPP was founded in 1972, two years before the ozone depletion theory was announced, in an attempt to discover what became of the relatively non-reactive CFCs when they migrated into the atmosphere. Since 1974, it has concentrated its work on the ozone depletion theory. The FPP is comprised of the world's major CFC producers, including the five U.S. producers, as well as their European and Japanese counterparts. Since its inception, the FPP has funded approximately $10 million of work by independent researchers of the highest reputation. While industry's effort continues, S.517 would require EPA and the National Academy of Sciences to continue their own programs of research in these and other areas of uncertainty.

No Risk in Waiting

There would have to be the most compelling reasons to proceed to regulate CFCs in the face of such uncertainty. S.517 would very sensibly require EPA to postpone regulation of CFCs until such time, if ever, as a proper scientific justification were established. The bill would not, however, require EPA to postpone regulation until health or the environment were actually harmed or until it was too late to forestall damage. Actual stratospheric ozone levels can be monitored and analyzed for any developing trend while the research required by S.517 is continuing. This analytical technique is called ozone trend analysis. Ozone measurements have been made at numerous stations throughout the world for the past several decades. These measurements have recently been statistically analyzed. To date, no depletion has been detected; in fact, the evidence shows that the ozone content of the stratosphere probably increased over the decade of the 1970s. The technique is sensitive enough to detect ozone depletion changes as small as 1.3 percent per decade.

The significance of ozone trend analysis is not so much that it may prove or disprove the ozone depletion theory (at least within the next few years), but rather that it provides an early warning system of changes in stratospheric ozone. The bill before you, S.517, would defer regulation while basic research on the ozone depletion theory continues under the safety umbrella of ozone trend analysis. Ozone trend analysis would indicate the occurrence of any change in stratospheric ozone and would trigger reconsideration of the need for regulation of CFCs. This is the very heart of S.517: there is no risk in waiting while science attempts to resolve the uncertainties associated with the ozone depletion theory. It is for this reason that the Alliance commends S.517 to you with confidence that in passing it you will do no disservice to the American people.

The Importance of CFCs

The uses of CFCs and the impact their regulation would have on our society and on the economy needs to be carefully examined. We will start by describing a number of their many applications. There is no way to appreciate fully the implications of EPA's proposal, and the need, therefore, for S.517, without an understanding of the wide use and importance of CFCs and of the severe limitations of those alternatives which are available.

1. The largest use of CFCs is as refrigerants in refrigeration and air conditioning systems. In 1979, approximately 270 million pounds of CFCs were used in these applications, roughly 33 percent of total domestic CFC production.

Nearly all households in the United States have one or more refrigerators and freezers. Bulk shipments of food and other products are made in 178,000 refrigerated vans and 27,000 refrigerated freight cars for eventual distribution in the economy, including over 40,000 supermarkets and nearly 180,000 other food stores in this country, as well as 250,000 restaurants and other commercial and institutional eating establishments, all with refrigerated storage facilities.

In addition to cooling homes, offices, factories, hospitals, nursing homes, hotels and other places of residence or employment, air conditioning is clearly essential today in our society. An entire section of the country, the so-called "Sunbelt," has grown and prospered in recent years in great measure because of the availability of air conditioning. Needless to say, many other regions of the country are equally dependent in season. In addition, many quite important industires could not survive without air conditioning as an integral part of their processing techonology. Textiles, printing, pharmaceuticals, computers, and telecommunications equipment, are just a few examples of such industries.

No other refrigerant can be substituted for CFCs in existing refrigerators and air conditioners. In fact, other available refrigerants would be too hazardous for use even if existing refrigerators and air conditioners could use them. Prior to 1931, refrigeration equipment used refrigerants such as methyl chloride, ammonia, and sulfur dioxide. These materials are relatively toxic and some are flammable or explosive. Efforts to develop safe alternatives for CFC refrigerants have to date not been successful.

2. CFCs are used in mobile air conditioning. In 1979, approximately 105 million pounds of CFCs, or roughly 13 percent of total domestic CFC production, were used in mobile air conditioning applications, such as automobiles and trucks. Virtually all mobile air conditioning equipment is designed to use CFC-12 ex-

clusively. No other refrigerant can be substituted in this equipment.

3. Rigid insulating foams are another major application of CFCs. In 1979, they accounted for 75 million pounds of CFCs, about nine percent of total domestic CFC production. CFCs are used as expanding agents to produce the foams.

Rigid insulating foams are used primarily for thermal insulation. Typical applications are in commercial and residential construction and in water heaters, refrigerators, and freezers. The continued presence of CFCs in the closed foam cells is what gives these foams their superior insulating characteristics.

With present techonology and materials, there is no available substitute for CFC blowing agents in rigid insulating foams. If EPA regulations of CFCs were to make rigid insulating foams less available or unavailable, industry would have to use such alternates as fiberglass, foams made without CFC blowing agents, or wood pulp products. The result would be a more expensive or less energy efficient product.

4. CFCs are used as an expanding agent for flexible polyurethane foams. In 1979, approximately 50 million pounds of CFC were used in these applications, roughly six percent of the total domestic CFC production.

Flexible polyurethane foam is used as padding for furniture and for seats in the interiors of transportation equipment. It has essentially replaced the cotton/steel spring construction formerly used in furniture manufacture. It is also used for bedding, textile laminates, carpet underlay, gasketing, sound deadening, and packaging.

There are two possible substitutes for CFCs in flexible polyurethane foam applications: water and methylene chloride. Neither of these alternatives have the favorable economic and toxicity characteristics of CFCs.

5. CFCs are used as a blowing agent for polystyrene, polyethylene, and phenolic foam. In 1979, approximately 40 million pounds of CFC were used in these applications, or about five percent of the total domestic CFC production. These products are used in everyday items such as protective and cushion packages, egg cartons, disposable dinnerware, and industrial containers. These containers are sanitary and nonabsorbent.

Two possible alternatives to CFCs for blowing polystyrene foam are pentane and chemically-reactive blowing agents. However, both have serious drawbacks. Pentane is flammable and highly explosive. Chemical blowing agents can be used, but they are expensive and might make the product uncompetitive. Elimination of CFC foam products would probably force a return to wood pulp products, which are far less sanitary since they absorb moisture and organic matter from food.

6. CFCs are used as cleaning agents or solvents. In 1979, about 100 million pounds of CFCs were used in solvent applications, or about 16% of the total domestic production. CFC solvents are most frequently used where high reliability cleaning is essential, as in the manufacture of semi-conductor, aircraft, computer, medical, aerospace and military devices.

The nonflammability and low toxicity of CFC solvents provide a major contribution to worker safety. Hydrocarbon solvents might be used in some applications to replace CFCs, but they are generally flammable and therefore would require additional plant investment in explosion-proof equipment. Chlorinated solvents can sometimes be substituted, but in some cases they can damage many plastics and elastomers that CFCs do not harm. Water is also an alternative solvent for some cleaning operations, but critical cleaning of electronic, medical, space program and defense items is not compatible with water, which leaves residual soil behind.

7. CFCs are used as liquid food freezants. CFC freezants result in very rapid freezing of the food, which is advantageous for freezing fragile, difficult-to-freeze, food products. The primary products frozen by CFCs are cob corn, french sliced green beans, seafood (primarily shrimp

and clams), berries, and small portions of meat. In 1979, approximately 10 million pounds of CFC were used in this application, or roughly one percent of the total domestic CFC production.

8. CFCs are used as the inerting gas for certain medical sterilants. For example, ethylene oxide (EO) is an extremely effective sterilizing agent and is preferred by hospitals and medical-device manufacturers for equipment sterilization. However, its flammability in its pure form severely limits its use. Consequently, where the sterilizing ability of EO is required, but where its flammability cannot be tolerated, EO is mixed with an inerting agent, usually CFC-12. In 1979, approximately 15 million pounds of CFCs were used for this application, or roughly two percent of total domestic CFC production.

Regulatory Impacts

This survey of CFC applications should make it clear that curtailment of their availability would have a permanent and enormous adverse impact on our economy and on the quality of our lives.

About $500 million worth of CFCs are used each year in the United States.

More than 780,000 jobs are directly dependent upon CFC use.

About 260,000 businesses, most of them very small, use CFCs.

The total value of goods and services that use CFCs exceeds $28 billion a year.

But these statistics do not describe the human impacts. Just about every home in America has a refrigerator. That would not be true were it not for CFCs. Just about every American takes it for granted that refrigerated and frozen foods will be available in local supermarkets. They are there because of CFCs. Millions of Americans work in office buildings and factories which were designed on the assumption that they would be air conditioned and consequently would be unusable if CFCs were not available.

Similarly, large areas of our country depend on CFCs for the air-conditioning which makes the hot and humid season liveable at home and in transportation to work. The health, comfort and productivity results of this air-conditioning would appear to be virtually immeasurable. Indeed, in health-related applications alone, in hospitals and other institutions, and in the homes of those disabled, the contributions of air-conditioning would appear to be self-evident and irreplaceable.

At a time when we are acutely conscious of our balance-of-payments, regulation of CFCs would also create serious problems in international trade.

In discussing its proposed cap on domestic production of CFCs, EPA said in its ANPR that "it appears unlikely that firms would continue exporting [CFCs] because they would be placed in an unfavorable pricing position in the foreign CFC market." That is correct. The CFC business, both domestic and abroad, is extremely price sensitive. A small increase in price by one supplier has in the past resulted in dramatic volume shifts to lower-priced suppliers. Since a cap on U.S. production would inevitably raise domestic prices, U.S. producers would be in the unenviable position of trying to compete in export markets with a commodity chemical at a higher price than that asked by foreign firms. The result, of course, could be additional U.S. trade deficits.

Similarly, U.S. manufacturers of CFC-dependent products, such as refrigerators and air conditioners, could be priced out of their present export markets even if they still had products to sell in those markets. The opposite problem would exist for domestic manufacturers of CFC-dependent products who compete in the U.S. market against foreign imports. The domestic manufacturers would have to pay a premium for CFCs under an EPA-imposed cap. However, foreign manufacturers producing goods abroad which are dependent upon CFCs (which might range from frozen shrimp to automobile air conditioners) would pay "normal" CFC prices.

Finally, any limitations on the availability of CFCs would have significant energy-related effects. These would include efficiency losses associated with using substitutes in mobile air conditioning, in residential and commercial air conditioning and refrigeration, in insulation, and for food freezing. A study conducted by Battelle Columbus Laboratory for an Alliance member company estimated that a complete ban of CFCs might result within ten years in an annual increase in U.S. energy consumption equivalent to 226 million barrels of oil. That corresponds to 12.0 percent of total U.S. crude oil imports in 1980, or about 43.0 percent of the current annual oil production from Alaska's north slope. In view of our nation's energy concerns, there would have to be the most compelling reasons for a regulatory program which could involve those kinds of energy penalties.

Futility of Unilateral Regulation

If there were depletion of stratospheric ozone due to CFCs, and if that depletion were to create an unreasonable risk to human health, the problem would be truly an international one. CFCs are produced and used worldwide. It ultimately would make no difference where they were used and released into the environment; any potential depletion of the ozone layer would impact all countries. Solutions to the problem, if a problem exists, must therefore be international. No single country could specifically protect "its" ozone layer even if all use of CFC within its borders were stopped. Further, no single country could reverse any worldwide problem of ozone depletion through its unilateral regulation. This includes the United States, which only accounts for about one-third of total world CFC production. As EPA noted in its ANPR, "No single nation accounts for a large enough portion of world use or production to be able unilaterally to control ozone depletion."

It is noteworthy that no other country is proposing a program of control of CFCs like EPA's. In fact, only a handful of countries (none of which are major producers) have gone as far as EPA in limiting the use of CFCs as aerosol propellants. Most other countries remain unconvinced of the need for further regulation at this time. The European Economic Community (EEC), for example, which accounts for about one-third of total world production, concluded in a June 1980 report that "a regulatory delay of up to five years can be reasonably accepted." Further, in comments on EPA's October 1980 ANPR, the EEC stated that "with regard to the validity of the ozone depletion theory, [it] cannot endorse all of the findings suggested by EPA," and that "EPA has not considered the numerous other studies on this problem which have been conducted outside the United States."

For these reasons, the Alliance strongly supports the position of S.517 that regulation of CFCs be conditioned either upon the imminence of a clear hazard or upon development of an international scientific assessment and, if needed, the establishment of an effective international control program. Obviously, if analysis of actual measurements such as ozone trend analysis tells us a problem is developing, we must act without waiting upon the rest of the world. Absent such evidence, however, it would be quixotic to impose the burdens of an ineffective unilateral regulation on the American people. We applaud S.517's recognition of this fact.

The Alliance appreciates the opportunity to present testimony in support of S.517. We should also note that the Alliance's comments on the ANPR (along with those of many others affected by EPA's proposed production restrictions) are available if the Committee desires additional information on the subjects we have touched on.

STATEMENT OF DR. THOMAS C. EDWARDS, ROVAC CORP., ROCKLEDGE, FLA.

CFC/OZONE DEPLETION PROBLEM

THE FACTS: AN APPROACH TO A MAJOR PART OF THE SOLUTION

BACKGROUND: CFC'S, OZONE AND AIR CONDITIONING

"All human life depends upon satisfactory growth of plants and animals used for food. We know that release of CFC's (chlorofluorocarbons) -- mainly CFM's (chlorofluoromethanes) -- into the atmosphere acts to deplete ozone in the stratosphere, although we can only estimate approximately by how much. We know that stratospheric ozone depletion will increase the amount of DUV (damaging ultraviolet radiation) reaching the ground from the sun, and by how much. We know that increased DUV can have unfavorable effects on plant growth and on life near the surface of our seas, although our information is incomplete and qualitative. We do not know at what annual release of CFC's the consequences for the world's food would be intolerable, but we know that there is such a level. Thus, though the size of the danger is uncertain, it is only prudent to hold down or reduce the total release of CFC's due to human activity." This passage opens an extensive report prepared by the National Research Council (NRC) of the National Academy of Sciences (NAS) entitled: Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons, 1979.[1]

EARTH'S OZONE LAYER: BOTH VITAL AND FRAGILE

The earth's ozone layer, made up of a very chemically active form of oxygen (O_3), has the unique property of protecting the surface of the earth from the intense hard ultraviolet radiation emitted by the sun's nuclear furnace. Fluorocarbons are the refrigerant chemical now used in virtually all air conditioning and refrigeration systems the world over. Although air conditioning and refrigeration systems are "closed", the CFC refrigerant leaks out slowly (more in automotive systems, less in home refrigerators, for example) and becomes entrapped in the earth's atmosphere and, eventually, through the convective activity of the weather, reaches the upper level of the stratosphere into the earth's ozone layer. The CFC modelcules, which are made up of fluorine and chlorine atoms chemically fused with various hydrocarbons, break up due to the intense radiation from the sun. When this happens, the fluorine and chlorine atoms, which are quite chemically active, become free to interact with the also chemically active ozone. The chemistry of this interaction is quite complicated, but the end result is that only trace quantities of chlorine and fluorine convert much greater quantities of oxygen from the O_3 (ozone) form to the more stable O_2 form. One molecule of chlorine, for example, can be responsible for the destruction of 10,000-50,000 ozone molecules.[2] The problem is that O_2 is essentially transparent to damaging ultraviolet radiation -- therefore the DUV reaching the earth increases and endangers life as we know it on earth. According to a recent chemical trade journal article,[3] some 700 million pounds of CFC's were produced in 1980. When one considers that if the ozone shield were compressed to the normal pressure of the atmosphere at sea level, the layer would only be about as thick as a dime,[4] the magnitude of the problem can be somewhat better appreciated.

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[1] National Academy of Sciences, Washington, D.C., Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons, (1979).

While the NAS has not yet been able to precisely define the ozone depletion rate (and probably could not -- until it was too late), the following summary "Key Findings" excerpted from the NAS report (Ref. 1) presents a wider view of the situation:

> *If the release of CFC's were to increase at an annual rate of 7 percent between the years 1980 and 2000 (equivalent to doubling*

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[2] F.S. Rowland and M.J. Molina, Nature Magazine, Article: "Stratospheric Sink for Chlorofluoromethanes: Chlorine Atom Catalysed Destruction of Ozone, (June, 1974), vol. 249, page 810.

[3] Chemical News Magazine, Article: "Fluorocarbons Are an Issue Again", (June, 1981), page 31.

[4] Edward Edelson, Popular Science Magazine, Article: "The Great Ozone Debate, (June, 1977), page 82.

the release rate in each decade), it is most likely (3 chances in 4) that the ozone depletion would eventually exceed 30 percent.

—

A decrease in average ozone concentration will increase the average intensity of biologically damaging ultraviolet radiation (DUV) in natural daylight. Such an increase in DUV would provide no established benefits and would clearly be detrimental both to human health and to nonhuman biological systems. A 16 percent decrease in average ozone concentration will produce a DUV increase of about 44 percent at midlatitudes, while a 30 percent ozone depletion would increase DUV by about 100 percent.

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With any specified pattern of sunlight exposure in the more susceptible part of the population, skin-cancer incidence rates would be higher under conditions of depleted ozone. In the United States, with present habits of personal exposure, a 16 percent ozone depletion would result eventually in

- *several thousand more cases of melanoma per year, of which a substantial fraction would be fatal, and*
- *several hundred thousand more cases of nonmelanoma per year.*

—

Crop yields from several kinds of agricultural plants are likely to be reduced as a result of a 16 percent to 30 percent ozone depletion. Present data do not permit a quantitative estimation of the expected production losses but do show differences in the ultraviolet sensitivities of different plants cultivated in the United States. Since nonagricultural plants show ultraviolet sensitivities in the same range as do agricultural plants, effects of ozone depletion on wild and cultivated plants should be similar.

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Larval forms of several important seafood species, as well as microorganisms at the base of the marine food chain, would suffer appreciable killing as a result of a 16 to 30 percent ozone depletion. Present ignorance of ultraviolet penetration into the waters that they inhabit and of the depth distribution of the organisms precludes an estimate of actual losses.

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> *Climatic effects of continued CFC release at the 1977 rate would include an average warming of the earth's surface by a few tenths of one degree Celsius before the middle of the twenty-first century, as well as changes in the stratospheric temperature patterns, which in turn affect ozone chemistry.*

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CFC's were originally developed in 1928[5] specifically as refrigerants for air conditioning and refrigeration. Subsequently, however, these compounds found wide commercial use not only as a refrigerant but also for such diverse applications as pressurized paint can dispersants, hair spray and deodorant spray propellants and insulation foaming agents. In fact, slightly over half of the U.S. production of CFC's in the past decade were used in non-refrigerant applications. In 1978, after much study and many hearings, the U.S. EPA banned the use of CFC's in "non-essential" (mostly aerosol can) applications. At that time it was indicated that ozone depletion of approximately 7% could be expected at the then-believed CFC-ozone depletion rate. Subsequent 1978-1979 studies conducted by the U.S. National Academy of Science (NAS) and the National Aeronautics and Space Administration (NASA) increased the estimated depletion rate to be about 16% (see previous NAS "Key Findings" excerpts) -- twice the original estimate. Because approximately half of the total amount of CFC's were employed in "non-essential" applications, the new estimates of ozone depletion becomes approximately the same as it was before regulation of CFC use in aerosol cans. This simply means that the problem still appears as big as it ever did even though U.S. production of CFC's has been reduced by about half.

The EPA regulatory effect on the aerosol industry insofar as CFC's are concerned was two-fold:

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[5] Dr. Ralph C. Downing, RSC Magazine, Article: "If Not Fluorocarbons -- What are the Alternatives?", (December, 1977).

a. mechanical "pumps" were substituted for the pressurization effect of the CFC's, and

b. high vapor pressure non-toxic flammable hydrocarbons replaced CFC's as propellants.

Thus, there was only minor and momentary displacement in the aerosol industry as logical alternatives were substituted for CFC's and the aerosol industry continued to flourish. But what about the air conditioning and refrigeration industry? This industry is fighting hard[6,7,8] (perhaps quite understandably) against any possible curtailment of the production and use of CFC's. According to spokesmen for this industry, there is no viable alternative[3,9] to CFC use. This belief may have been true even as long as a year ago. However, it is certainly no longer true[10] -- as will be set forth subsequently.

Before proceeding with a discussion of this new non-CFC alternative, it is important to obtain an indication of the magnitude, popularity and energy consumption of air conditioning systems in the U.S. According to EPA report EPA-56011-76-009, entitled "Chemical Technology and Economics in Environmental Perspective", November, 1976, there are in existence (in the U.S. alone) some 45 million mobile (automotive) air conditioning systems. Industry estimates vary,

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[3] Chemical News Magazine, Article: "Fluorocarbons Are an Issue Again", (June, 1981), page 31.

[6] Air Conditioning and Refrigeration Business Magazine, Article: "New Fluorocarbon Study Spurs ARI Warning", (January, 1980).

[7] Automotive Cooling Journal, Article: "CFC Industry Organizes to Face Federal Regulations", (August, 1980), Vol. 23, No. 8, page 33.

[8] S.517, H.R.1853 (Senate and House Bills).

[9] Air Conditioning, Heating and Refrigeration News Magazine, Article: "Chance to Squelch CFC Regulation if Wide Industry Support Received", (December, 1980).

[10] Dr. Thomas C. Edwards, et al, SAE Technical Paper No. 810505, "Preliminary Development of a High Efficiency Low Vapor Pressure Non-Fluorocarbon Air Conditioning Compressor", (February, 1981).

but it appears safe to state that about 10% mileage penalty (1-2 mpg) is imposed by the use of auto air conditioning. Assuming vehicles average about 3000 air conditioned-miles per year, this amounts to about 1.5 billion gallons of fuel per year required for auto air conditioning. The cost? -- about two billion dollars.

In round numbers, for the past decade, approximately two million home air conditioners and three million window air conditioners have been manufactured and put into service each year.[11] Because the service life of most stationary air conditioners is on the order of 10 years, approximately fifty million home or window air conditioners are used in the U.S. The average coefficient of performance of these stationary air conditioning units is on the order of two and they consume electrical energy approximately 1700 hours each year. (This amounts to about 19% operation time per year). The result is the consumption of some 200 billion kilowatt hours per year. At an average cost of about 7 cents per KWH, the annual cost of operating these air conditioning machines in the U.S. is on the order of 17 billion dollars.

In total then, U.S. consumers spend on the order of 20 billion dollars each year air conditioning cars and homes -- or about one hundred dollars per year for every man, woman and child in America.* Utilization of the new high efficiency ROVAC non-CFC air conditioning system technology would save some seven billion dollars each year.

Next consider the structure of the industry that provides the conventional CFC-based comfort systems.

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[11] Appliance Magazine, Appliance Statistics, (Dana Chase Publication, January, 1981), page 22.

*As a matter of comparison, each American pays about 20 dollars per year for the entire U.S. space program.

THE BASIC STRUCTURE OF THE AIR CONDITIONING INDUSTRY

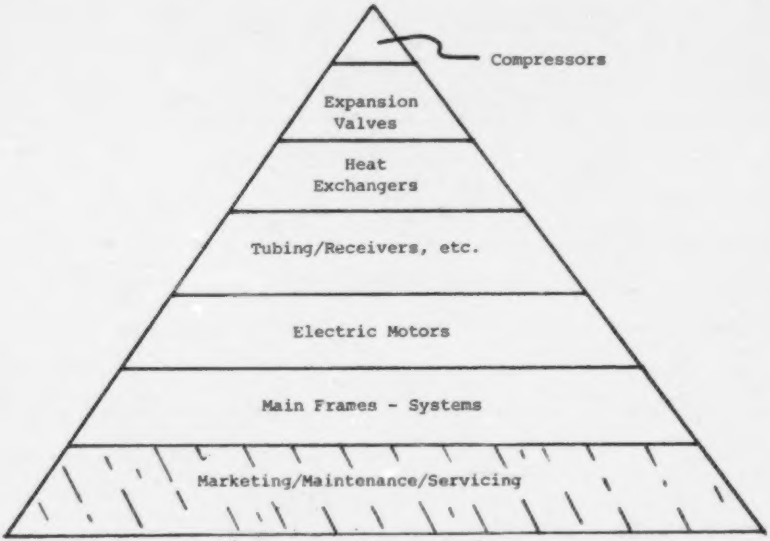
In order to obtain an indication of the basic structure of the air conditioning industry, one must look at a listing of the various main components and subassemblies of an average air conditioning system. In general, air conditioning systems consist of eight main components. In the order of relative system significance (ignoring the refrigerant) these are:

1. Prime mover (electric motor for house use, auto engine for car use)
2. Compressor
3. Heat exchangers
4. Fans/fan motors
5. Expansion valve
6. Interconnecting tubing
7. Receiver/accumulator/dryer
8. Main frame/system assembly

The relative preponderance of manufacturers of these components now existing in the U.S. can be listed in the following order as a function of relative number of manufacturers:

1. Compressors (perhaps one half dozen in the U.S.)
2. Expansion valves (one half dozen)
3. Heat exchangers (several dozen)
4. Tubing/receivers/accumulators/dryers (several dozen)
5. Fans/fan motors (dozens)
6. Electric motors (on the order of 50)
7. Main frame fan/system assembly (on the order of 50)

Diagramatically, this heirarchy, in terms of relative numbers of manufacturers, can be illustrated as a pyramidal structure as shown on the following page. Also indicated in this illustration is the foundation of the industry (as with most industries) -- the marketing/service function.


Compressors
Expansion Valves
Heat Exchangers
Tubing/Receivers, etc.
Electric Motors
Main Frames - Systems
Marketing/Maintenance/Servicing

Schematic Depiction of the
Air Conditioning and Refrigeration Industry:
Relative Number of Manufacturers

Thus, it can be seen that at the top of the structure is a relatively small number of compressor and expansion valve manufacturers, a larger number of heat exchanger manufacturers, etc. While this illustration is obviously a simplification, it does reflect the basic nature of the industry and sets a meaningful stage for understanding what effect the introduction of a new (non-CFC) technology would have on the air conditioning industry.

From an overall economic standpoint, if one had a choice as to an alternative technology, certainly the choice would be one that would have minimum adverse impact on the existing industry and yet possess no disadvantages such as poor efficiency, high unit cost, high capital investment requirements, poor safety or an alternative adverse environmental impact. The next Section introduces such a technology (Ref. 10).

THE ROVAC HIGH EFFICIENCY NON-CFC AIR CONDITIONING SYSTEM

Background

The ROVAC air conditioning system technology is an outgrowth of a unique air cycle air conditioning machine that was the subject of a Doctoral thesis completed at Purdue University in 1970.[12] In 1972, The ROVAC Corporation was formed with the express mission being the development and commercialization of a simple non-CFC air conditioning system. In 1974, ROVAC became a public company and has, on various occasions, raised additional private and public monies. This has amounted to a total of about $5,000,000. In addition, various branches of the U.S. Military has supported the development of allied ROVAC technology for the possible thermal management application aboard high performance aircraft. In all, some $6,000,000 in high risk capital has been invested in ROVAC technology. Now this investment has yielded precisely the alternative air conditioning technology needed now.

The ROVAC System

The ROVAC system in many respects is very similar to the conventional high pressure CFC-based vapor cycle air conditioning system. It differs fundamentally in that it operates very efficiently at very low pressures (on the order of one-sixth that of conventional systems) with a variety of non-CFC naturally-occurring hydrocarbons. In actual side-by-side cooling performance tests of two Japanese automobiles, one equipped with the new ROVAC non-fluorocarbon air conditioning system and an identical automobile equipped with a conventional R-12 fluorocarbon air conditioner, the ROVAC system exhibited superior cooling performance in extensive road tests, affirming the results achieved in earlier laboratory testing. In every case, the ROVAC system provided greater cooling during driving tests conducted in humid 90-degree plus weather on Florida highways and in heavy traffic. The tests were carried out by ROVAC technicians, with Japanese automotive engineers present during most of the testing.

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[12] Thomas C. Edwards, A Rotary Vane Open Reversed Brayton Cycle Air Conditioning and Refrigeration System, PhD Thesis, (June, 1970).

With the exception of the conventional compressor, CFC refrigerant, and a "drier" element (used to reduce the generation of hydrochloric and hydrofluoric acid inside conventional CFC systems), the ROVAC system requires all the other components used in conventional systems. These components (e.g., heat exchangers, motors, fans, main frames, etc.) are very similar, and in some cases, identical to those of conventional CFC air conditioning and refrigeration systems. This is an important fact when the structure of the existing air conditioning industry is considered because the clear conclusion (in spite of the position of special interests) is that only a very small fraction of the entire industry would seriously feel the impact of legislation curtailing CFC use. Specifically, those affected adversely would be limited primarily to the few CFC compressor manufacturers and the four manufacturers of CFC's.

Recalling that some 100 million air conditioning machines are in service requiring some 20 billion dollars each year to operate, it is worth re-emphasizing that because of the 35-40% efficiency superiority (Ref. 10) that this new technology represents, if fully integrated into use, would result in an annual savings of 7 billion (today) dollars in, say, a decade, not to mention the cumulative savings occurring over the next 10 years or so that would be required to complete such integration.

As an aside to this issue, it is interesting to note that the air conditioning industry has been suffering from a sagging growth pattern. This can be attributed to the escalating costs of energy. The introduction of an energy-efficient air conditioning system technology, would, in all likelihood, result in a healthier air conditioning industry.

CLOSURE: A REALISTIC SOLUTION

From the foregoing, the following facts can now be summarized:

- Life as we know it on this planet is possible only because of the earth's protective ozone layer which required eons to form during primordial times.
- The CFC industry disagrees with the rates of ozone depletion predicted by the National Academy of Sciences and NASA and is lobbying actively to disarm EPA's mandate to protect the environment insofar as CFC's are concerned.
- There now exists an energy-efficient non-CFC air conditioning and refrigeration technology that is very similar to existing systems.
- Integration of this new technology into the existing industry would present, in fact, only relatively minor economic displacement from an overall industry viewpoint.
- Adopting this new technology would not only further preserve the earth's ozone layer, but conserve vast quantities of energy as well.

What can be done to solve the problem? These recommendations are set forth:

1. Publicize the global CFC/ozone problem; label CFC-containing products
2. Defeat S.517 and H.R.1853
3. Pass S.460 (copy attached)
4. Obtain agreements with The ROVAC Corporation to license its technology on fair and equitable terms to proper constitutents of the CFC industry (primarily the compressor manufacturers but also to certain large system assemblers.)

SAE Technical Paper Series

810505

Preliminary Development of a High Efficiency Low Vapor Pressure Non-Fluorocarbon Air Conditioning Compressor

Thomas Edwards,
William Clark,
and Robert J. Cavalleri
The ROVAC Corp.

International Congress and Exposition
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Preliminary Development of a High Efficiency Low Vapor Pressure Non-Fluorocarbon Air Conditioning Compressor

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THE REVERSE BRAYTON (AIR CYCLE) IS, theoretically, an efficient cycle for environmental control system applications. In order for this system to be feasible, however, on an energy competitive manner with the conventional vapor cycle system, very high compressor and expander efficiencies must be realized.

The necessity to develop very high compressor/expander efficiency devices for use in the reverse Brayton (air cycle) (1,2)* has resulted in an advanced technology utilizing rotary vaned, large volumetric through-put, gas-handling machinery. Recent application of this technology to the conventional vapor cycle has resulted in the preliminary development of a high efficiency competitively-sized, non-fluorocarbon vapor compressor. This is an important environmental development because of the mounting evidence that fluorocarbon compounds are depleting the Earth's ozone layer and the clear need for energy efficiency in all areas of energy conversion. Further, because the vapor cycle system is well developed and widely understood, this technology can be applied to commercial products in a relatively short time.

The following is a brief description of the machine developed, the associated calorimeter test facility and test procedure along with laboratory test performance results, both with R-11 (a fluorocarbon) and isopentane (C_5H_{12}) (a hydrocarbon).

The compressor discussed herein is a rotary vane, positive-displacement, constrained vane device. The evolution of the machine and its configuration is rooted in the high efficiency compressor/expander technology developed for use in the air cycle. An example of such a machine is shown in Figure 1.

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*Numbers in parentheses designate References at end of paper.

ABSTRACT

The development status of a compact large displacement non-fluorocarbon high efficiency compressor is reported. The compressor developed is a positive displacement, rotary constrained vane machine. Compressor performance results using two different refrigerants are reported. One refrigerant was a hydrocarbon whereas the other was a fluorocarbon. Data was obtained using a water calorimeter test stand. Test results demonstrated COP's in the range of 3.5 to 4.5 with both the non-fluorocarbon and fluorocarbon refrigerants at air conditioning test conditions. Maximum overall compressor efficiencies of slightly over 80% were obtained.

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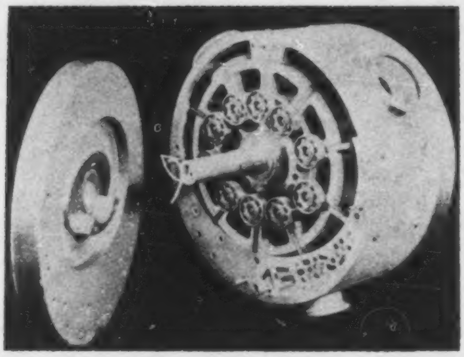

Fig. 1 - 607A Air cycle compressor/expander

The device shown in this figure exhibited compressor efficiency in the 90% range and expander efficiency as high as 84% (3)* using air as the working fluid.

The ROVAC compressor-only version of this type of machine, denoted the Model 225C, employs a unique internal contour that minimizes vane acceleration. The contour also provides for a large displacement per unit of occupied volume and excellent high-speed port flow characteristics.

Figure 2 is a photograph of the disassembled machine after being tested in the water calorimeter facility at ROVAC's facility in Rockledge, Florida.

The compressor tested here employs 10 vanes and has a design volume ratio of 5 which results in a pressure ratio of approximately 5:1 to 10:1, depending on the polytropic index of the working fluid. The volumetric displacement of the 225C is 43 cubic inches per revolution while the external envelope of the device is 355 cubic inches. The machine does not employ valves of any type.

Although the 225C was designed as a confirmation-of-theory device, its displacement was geared for use as a residential air conditioner. A smaller version, denoted the 227A has been designed for demonstration in an automotive application. The 227A employs only 6 vanes, has a displacement of 30 cubic inches per revolution and has an external envelope of 205 cubic inches. It is anticipated that this smaller machine will be tested in the winter of 1980 during which its performance map will be determined.

THE TEST FACILITY

A water calorimeter was used to accurately determine the compressor performance over various conditions. A schematic of the water calorimeter is shown in Figure 3. The test stand is equipped with a 15 horsepower General Electric DC motor mated with a SECO SCR DC electronic control system. The condensing heat exchanger consists of 4 refrigerant-to-water Edwards' coils connected in a parallel flow path. The evaporator heat exchanger is a tube-in-tube type built at ROVAC.

The shaft horsepower required by the compressor was determined by a Lebow 1605-2K calibrated strain gage torque sensor equipped with an angular velocity transducer. Pressures were determined by a calibrated Heise (CM-23428) gage. Temperatures were determined by Omega copper-constantan sheathed thermocouples. Water flow rates were determined by calibrated Dwyer rotameter type flow meters. All electronic sensor output was fed directly to a Kaye DR-2B data logger. This data logger conditioned thermocouple signals and recorded all other information.

TEST PROCEDURE

For all tests, the compressor was run at a constant speed of 1750 RPM. The performance was then mapped for various condensing and evaporating temperatures. A constant 15°F of subcooling was maintained at the expansion valve inlet. A constant 20°F of superheating was maintained at the compressor inlet. The evaporating temperature was obtained by manually

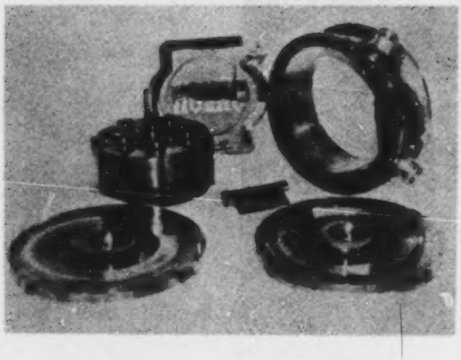

Fig. 2 - Model 225C non-fluorocarbon compressor

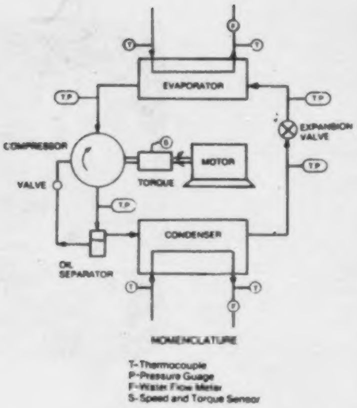

Fig. 3 - Schematic diagram of water calorimeter test facility

setting the expansion valve. The superheat was controlled by varying the quantity and temperature of the water flow onto the evaporator. The condenser temperature and subcooling was controlled by varying the quantity and temperature of water flow onto the condenser. Data was automatically recorded every 1 to 2 minutes after steady-state conditions were reached.

TEST RESULTS

The 225C was tested in the water calorimeter and mapped extensively using R-11 as the refrigerant. This was done in order to provide a baseline for comparison. Another performance map using isopentane was generated in order to determine the efficiency of the compressor while operating with a non-fluorocarbon refrigerant. Neither the compressor nor the facility was modified for the isopentane refrigerant. The results from these tests are presented in Figures 4 and 5. The data showed that, as expected, due to its higher density, R-11 produced slightly more capacity than isopentane. However, the coefficients of performance for the two refrigerants were basically the same. The data in Figures 4 and 5 indicates that COP's in the range of 3.5 to 4.5 are readily obtainable for conditions of interest for air conditioning applications. The compressor efficiency was determined by using the measured COP values in conjunction with theoretical COP values. The ratio of the measured COP value to the theoretical COP value is the overall compressor efficiency. Peak compressor efficiencies of 79% for the isopentane and 82% for the R-11 were obtained.

In order to shed meaningful light on the measured data, a comparison between the 225C performance and conventional R-12 and R-22 compressors was made. For this purpose, three common compressors having similar capacities at the same condition were chosen. These were

1) Sundstrand (Bristol) Model H20A353AB, a reciprocating type;
2) Fedders Model K55C15, a rolling piston type;
3) Frigidaire Model 12.6 cubic inch, an automotive "swashplate" type.

Using manufacturer's data, the COP of these compressors is compared to the 225C compressor data in Figure 6. For the Sundstrand and Fedders hermetic units, the COP supplied by the manufacturer was increased to account for motor inefficiency. Assuming the motor efficiency is 85%, the compressor COP became

$$COP_c = \frac{COP_{total}}{.85}$$

As seen in Figure 6, the 225C compressor demonstrated an efficiency increase of approximately 30% over conventional units at 40°F to 45°F evaporator temperature.

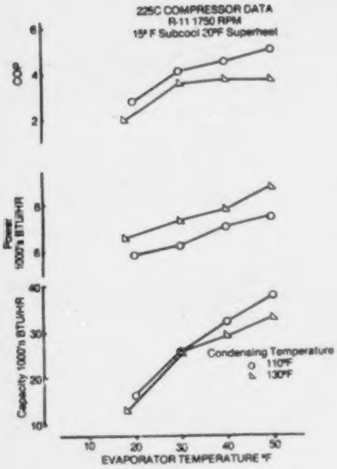

Fig. 4 - Compressor test data for R-11

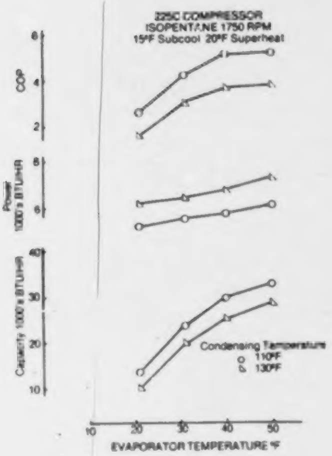

Fig. 5 - Compressor test data for isopentane

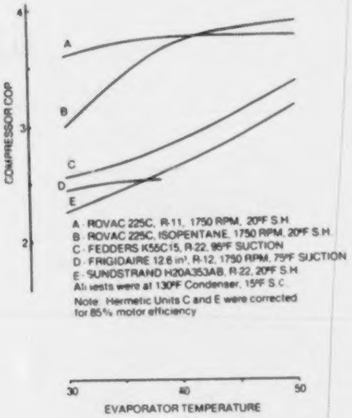

Fig. 6 - Comparison of standard commercial compressors

CLOSURE

While such issues as compressor performance optimization, production costs, durability and refrigerant-to-air heat exchanger design must yet be resolved, the results of this preliminary development program illustrates the fact that a non-CFC highly energy-competitive compressor now exists. This compressor performs equally well both with non-fluorocarbon and fluorocarbon refrigerants. Past and on-going experience in these particular areas of development has been positive and efforts to bring this technology to commercial fruition will continue. Additional tests indicate that the existing 80% level of efficiency can be improved upon. In fact, it is anticipated that efficiency values in the 90% range can be achieved by optimization of the 225C.

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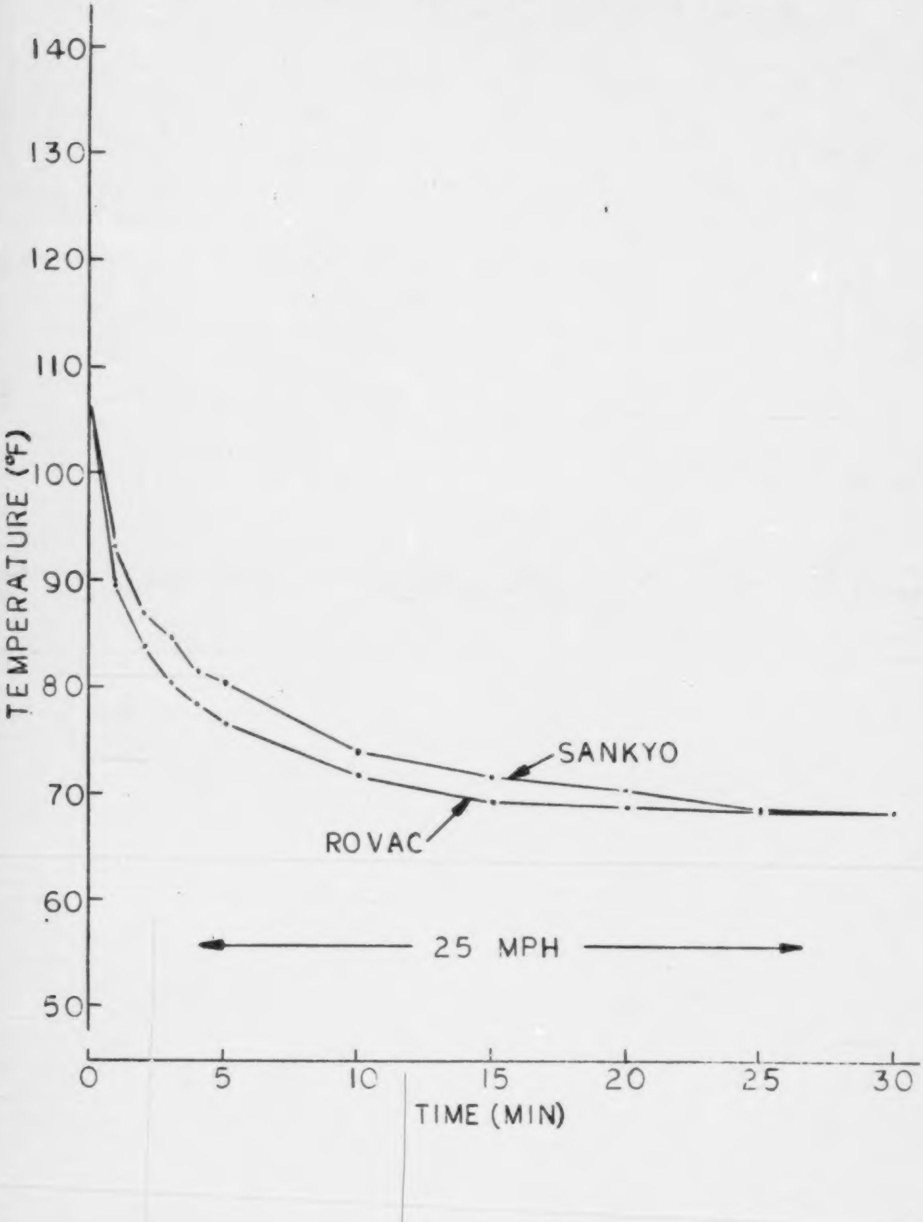
AUTOMOBILE AIR CONDITIONER
SIDE-BY-SIDE TEST 5/29/81
INSIDE CAR TEMPERATURE VS. TIME



AUTOMOBILE AIR CONDITIONER

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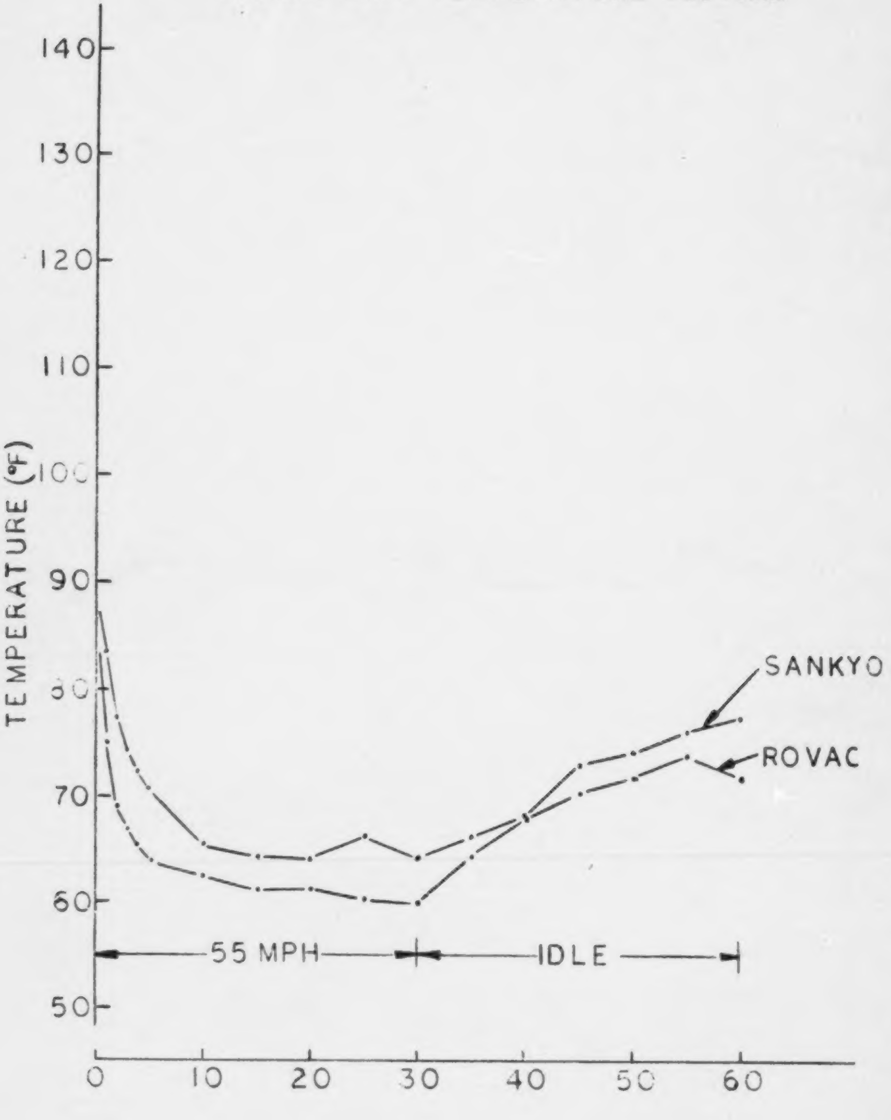

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND
AIR-CONDITIONING ENGINEERS, INC.

ASHRAE / 1791 Tullie Circle, N.E. / Atlanta, GA 30329 Telephone / 404-636-8400

Dr. Jack B. Chaddock, P.E.
President

Reply to: Mechanical Engineering &
Materials Science
Duke University
Durham, NC 27706
Tel / 919-684-2192

August 5, 1981

The Honorable Slade Gorton
United States Senate
Washington, DC 20510

Dear Senator Gorton:

On behalf of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), I congratulate you on your Subcommittee's recent hearings on chlorofluorocarbons. This issue is of great importance to the 40,000 members of our organization.

ASHRAE has had a Special Presidential Ad Hoc Committee studying the evidence on the chlorofluorocarbon issue to provide ASHRAE with an objective assessment. This special committee was comprised of three members from the private sector and three members from the academic community. The results of their investigation were presented to our Board of Directors.

ASHRAE did not seek to testify at your hearings but we would like to provide material based on our investigation of the issue into the hearing record. Enclosed are the findings of our Special Presidential Ad Hoc Committee including a policy statement approved by the ASHRAE Board of Directors on May 22, 1981.

ASHRAE stands ready to assist the Committee in any way we can. Please feel free to contact our Washington representative, Dr. J.E. Cox, at our Washington office.

Sincerely,

Jack Chaddock

:jb

POSITION STATEMENT
AND
ASSESSMENT OF THE OZONE/CHLOROFLUOROCARBON ISSUE

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) is a research oriented, voluntary society of over 40,000 members, who have professional concerns with heating, cooling, ventilation and refrigeration. It is a technical organization composed of consulting engineers, manufacturers, Government officials and educators, including approximately 4,000 members in 118 countries outside U.S. and Canada. ASHRAE is also associated with professional societies having similar interests in 22 other countries. An international member serves on the Board of Directors of ASHRAE.

It is therefore, appropriate for ASHRAE to provide input towards formulating a U.S. national policy on the global issue in question, i.e., depletion of the ozone layer by chlorofluorocarbons.

This input is provided in full light of the ASHRAE Charter and Bylaws, which read:

> "The Society is organized for the exclusive purpose of advancing the arts and sciences of heating, refrigeration, air conditioning and ventilation, the allied arts and sciences and related human factors for the benefit of the general public. To fulfill its role, the Society shall recognize the effect of its technology on the environment and natural resources to protect the welfare of posterity."

POSITION STATEMENT

As stated in ASHRAE's Bylaws, the Society shall recognize the effect of its technology on the environment to protect the welfare of posterity. Consequently, ASHRAE expressed its concern that environmental damage may be caused if the release of chlorofluorocarbons (CFCs) is found to cause significant depletion of the ozone layer. Further, ASHRAE offers to direct its technical expertise and resources, as appropriate, towards resolving the issue.

Because this theory remains highly controversial in the scientific community, and because precipitous regulatory action could be detrimental to the public, ASHRAE recommends careful evaluation of the CFC/ozone question. CFCs are essential for refrigeration and air conditioning and are a major contributor to energy conservation through their application in thermal insulation.

Therefore, after close examination of the theory that implicates CFCs in the depletion of the ozone layer and review of other available information, ASHRAE concludes that:

1. The theory has not been validated by experimental data.
2. Federal regulations of CFCs are not warranted at the present time with respect to ozone depletion.
3. Vigorous research programs to improve the understanding of stratospheric ozone and to determine the effect of ultraviolet radiation upon the earth's surface need to be pursued.
4. Depletion of ozone is a global concern and should be addressed with international consensus.

In view of the importance of the CFC/ozone issue and its potential worldwide impact, and because ASHRAE can contribute towards the resolution of the same, ASHRAE proposes to:

1. Develop guidelines to minimize inadvertent losses of CFCs during manufacturing and servicing of end products which utilize CFCs.
2. Actively encourage research, including the expenditure of a portion of ASHRAE research funds, to investigate alternatives to CFCs and methods of CFC reclamation from CFC-using products at the end of their useful lives.
3. Establish, by way of symposia and seminars in cooperation with its International Associates, a technical consensus which would serve the interests of all parties.

STATUS OF THE OZONE DEPLETION THEORY

Chlorofluorocarbons (CFCs) are synthetic chemical compounds that are used for a wide variety of essential purposes, including refrigeration, air conditioning and as blowing agents for thermal insulation. CFCs are known to be stable and there is evidence of their presence in the lower atmosphere. In 1974 a hypothesis was proposed that CFCs could migrate to the stratosphere, where ultraviolet radiation from the sun would decompose them and release chlorine, which in turn could act to reduce the ozone layer that protects the earth from potentially damaging ultraviolet radiation (UV-B).

The ozone depletion theory has led some scientists and federal government officials to conclude that continued use of CFCs will lead to a significant reduction of stratospheric ozone. Depletion of ozone could result in increased UV-B at the earth's surface which might increase skin cancer in humans, damage crops, affect aquatic life and possibly impact the global climate, which are all valid reasons for concern and caution. The theoretical projections, even though occuring over an extended period of as much as 100 years, are considered by some to be grave enough to require prompt government regulation and control of all current uses of CFCs.

The ozone depletion theory relies on theoretical chemistry and computer models to predict the effects of CFCs on the ozone layer. There are experimental data that CFCs are building up in the lower atmosphere and there is evidence of their migration to the stratosphere. Laboratory scale experiments have shown that CFCs could be decomposed and release chlorine when exposed to levels of ultraviolet radiation known to be present in stratosphere. Laboratory experiments also indicate that ozone is decomposed in the presence of chlorine. However, actual measurements have shown some increases in the concentration of ozone in the stratosphere, even though the theory predicts that some depletion should already have occurred. Such inconsistencies suggest major deficiencies or invalid assumptions in the theory. Examples of these include:

1. Models do not simulate the stratosphere. Without further research such models cannot be considered reliable.

   - The National Academy of Sciences (NAS) does not really claim that the one-dimensional (1-D) model calculations have been validated, although it gives the impression in the Principal Findings -- "Although there are a few exceptions, the comparisons between the models and measurement of substances in the present stratosphere is considered to be satisfactory - - -." (NAS, Ch & Tpt p. 1)
   - However, in the body of the report, NAS qualifies the above statement "comparisons between measurement data and modeling results (are) somewhat subjective and somewhat inconclusive. (NAS, Ch & Tpt p. 148)
   - Further on in the chapter "Theoretical models of the stratosphere", NAS explains several reasons why the models cannot be validated - "no data are available for verification;" "the quality of the model predictions can only become useful through a vigorous research program"; "reasonable agreement between model and observed ambient atmosphere does not imply that the perturbational sensitivity (predictive power) of the model will be correct." (NAS, Ch & Tpt pp. 165-166)
   - In the Principal Findings, NAS also gives an uncertainty range for the model predictions, viz., factor of six with a 95 percent confidence level. There are qualifications for this statement also.

- Error analysis "experiments (of the Monte Carlo Type) do not include potential errors introduced by the basic model structure, unknown or omitted processes, or any of a myriad of other potentially severe sources or error in addition to the estimated errors in measured chemical rate coefficients." (NAS, Ch & Tpt - pp. 166-167) Clearly, except for the errors in measured chemical rate coefficients, the myriad of other severe sources of errors cannot be quantified and their estimates can only be arbitrary.

In brief, it appears that the emphatic prediction of ozone depletion in the Principal Findings are incompatible with the qualifications and disclaimers in the main body of the report.

2. Basic assumptions are in question. The underlying assumption in blaming CFCs for ozone destruction is that there are no natural sources of chlorine input to the stratosphere, and that other man-made sources are also minor.

It has been recognized that if direct measurements show large amounts of chlorine species in the stratosphere, then it would constitute sufficient grounds to doubt the validity of the theory of ozone destruction by CFCs. (IMOS, Ex. Summary, p. 11)

- Experimental measurements in the stratosphere since 1977 seem to confirm that there are, at present, very large amounts of chlorine species which cannot be attributed to the releases of CFCs. (U.K. Report - paragraph 276)

- The validity of these high chlorine measurements are not disputed, nor are they dismissed as accidental phenomena. These measurements are straight-forward - the ozone layer is thriving in spite of the large amounts of chlorine. We can therefore surmise that the understanding of the stratosphere is at best quite limited and at worst may be erroneous.

  The NAS admits that these measurements are "totally inconsistent with the models and our understanding of the chlorine budget," (NAS Ch & Tpt - p. 52) and yet seems to disregard such experimental evidence in its final conclusions.
- The U.K. report is more specific in stating that "there are still important gaps in our understanding and knowledge of the processes that determine stratospheric composition. It follows that if we are not satisfied with our present ability to simulate the natural stratosphere, particularly on the grounds that there may be major errors or omissions in current theory, we must be very cautious in accepting quantitatively any predictions from accompanying perturbation experiments." (U.K. Report - paragraph 280)

3. Basic chemistry needs reexamination. All the estimates of ozone depletion by CFCs are based on the chemical reactions believed to occur in the stratosphere. In the past, these estimates have varied each time the reaction rates of key processes have been remeasured.

- As examples, ClO NO_2 (chlorine nitrate) caused a reduction of ozone depletion by a factor of 1.85. Subsequently, the reaction $NO+HO_2$ caused the prediction to increase by a factor of two. Obviously this raises the question as to the . . . "assurance . . . we have that the present reaction scheme is reasonably complete, i.e., that no important species, reaction steps, or multiple pathways for current reactions have been omitted?" (NAS Ch & Tpt - p. 31)

- An example of omission of possible reactions is the chemical species HOCl. The reaction schemes considered by NAS for the photolysis are the following:

  $$HOCl + h\nu \rightarrow Cl + OH$$

  $$HOCl + h\nu \rightarrow ClO + H$$

  Based on these product channels, NAS states that "most of the laboratory studies on this compound indicate that it will be broken up relatively rapidly by sunlight and therefore will not provide a significant hiding place for stratospheric chlorine." (NAS, P. 48)

  However, the U.K. report suggests a third product channel, $HOCl + h\nu \rightarrow O + HCl$ and concludes that if a mere ten percent of HOCl photolyzes by this route, it "would be sufficient to reduce ozone depletion estimates by a factor of 3." (U.K. Report - paragraph 329)

- Similar to the preceding example of HOCl, there apparently are several other unresolved questions in the chemistry of stratosphere, for which the U.K. report states that "until the major problems of the chemistry are resolved, stratospheric ozone depletion estimates must be considered highly uncertain." (U.K. Report - paragraph 330)

4. Application of chemistry ignores the real world. Quite apart from errors in the measurements of chemical reaction rates, whether the reactions are real or speculative, it is important these reaction rates be properly used in calculating their effects on ozone depletion.

- The 1-D model calculations do not use the data properly because "the chemical reactions are represented as occurring between the average concentrations of each chemical species. In the real world reactions occur between chemicals having their instantaneous local concentration." (NAS, Ch & Tpt pp. 50-51)

The U.K. report also covers the same subject, only more explicitly by stating "The errors introduced by averaging the chemical terms . . . . could negate in its application to model calculations, all the careful laboratory work on rate constants." (U.K. Report - paragraph 237)

- NAS assigns a factor of uncertainty to account for this approximation, but there is a difference of opinion on this matter. The U.K. analysis points out that uncertainties for modeling procedures cannot be quantified and "the effective rate of reactions in the model calculation contain errors whose magnitude has not been established." (U.K. Report - paragraph 434)

5. 1-D models distort and exaggerate ozone depletion. Ozone in the stratosphere is not uniformly distributed. Much larger amounts are found in the polar regions. Even in the polar winter, when no ozone can be formed because of absence of sunlight and when destruction is the only phenomenon, larger amounts of ozone still occur. This is attributed to transport of ozone from the tropical stratosphere, where it is formed in large amounts.

Much ozone is transported, so are other species; in particular, nitrogen oxides or oxides of chlorine, which are suspected to be destroyers of ozone. The net result is that much of the ozone depletion is expected to occur at the poles, and in the late winter.

Averaging the depletion at the poles and in the polar winters to obtain one figure of global average certainly distorts the phenomenon and furthermore, it exaggerates the depletion where it counts, in the equatorial and mid-latitude region where most people live and where most plants grow. In fact, the U.K. report says that "a single average figure for ozone reduction is an over-simplification," and that "significant variations of the ozone reduction with latitude and season are to be anticipated." (U.K. Report - paragraph 436)

6. Increases of UV-B may be only half of that predicted by NAS. The possible consequences of CFCs are not based upon ozone depletion per se; rather they are based upon the sequential consequences of such depletion. These include: (a) increase in UV-B reaching the earth's surface, and (b) the perceived effects of UV-B upon humans, plants and aquatic life.

- NAS has assumed that the fractional increase in UV-B is two times the fractional decrease in ozone (physical amplification factor). Apparently this is predicated from laboratory data applied to a 1-D model.
- The U.K. report presents an equivalent analysis based on 2-D model results, which apparently simulate the present day ozone distribution including the hemispheric asymmetry. Their calculations show that the physical amplification factor is less than one, i.e., half of the number used by NAS. (U.K. Report - paragraph 419)

7. Experiments on the effects of UV-B on non-human organisms are unrealistic. In the appendices of the NAS report, a series of problems associated with the experimentation to determine the effects of UV-B on plants and aquatic species are identified.

Most experimentation has used filtered sunlamps, the spectral qualities of which do not simulate solar radiation for "any combination of solar zenith angle and ozone level." The visible portion needed for photosynthesis or DNA repair is one-tenth of that available from sunlight, whereas the ultraviolet portion is far too strong - more than that predicted for extreme ozone depletion. (NAS Report - p. 319) It is no wonder, then, that bacteria, algae, protozoa, and small invertebrates were found to die within only a few hours of exposure to the fluorescent lamps. The experimentation is simply not realistic.

- To its credit, the NAS report clearly states the uncertainty of the effect of UV-B on plant and aquatic ecosystems which "stems partly from ignorance of the proper weighting function for different wavelengths to be used in comparing solar and artificial source irradiations but mostly from the limited scope, and in some cases incomplete design of experiments and the lack of corroboration by independent investigators . . .(which) . . . in turn, stem from the haste with systematic longer-range program to answer well-defined questions." (NAS Report - p. 69, 70)

ESSENTIALITY OF CHLOROFLUOROCARBONS

Chlorofluorocarbons (CFCs) are essential to the use of refrigeration and air conditioning in our economy. CFCs are the refrigerant, or working fluid, in nearly every type of refrigeration or air conditioning system in use today. In addition, CFCs are widely used as the blowing agents for rigid, closed cell foam used as thermal insulation in these systems. The widespread use of CFCs is a result of their unique characteristics of safety, performance, reliability, energy efficiency and cost effectiveness.

Refrigeration Uses

Most refrigeration systems are of the mechanical vapor compression type designed to use CFC compounds, typically 12, 502, and 22. Refrigeration systems include home refrigerators and freezers, commercial refrigeration systems, and transportation systems for processing, storing, display and preservation of our food supply. These systems are used in millions of homes, thousands of refrigerated vans, trucks and rail cars, as well as supermarkets, food stores, food processing plants, warehouses and restaurants. The widespread availability of fresh and/or frozen meat, poultry, fish, dairy products, fruits, vegetables and produce is directly dependent on refrigeration systems using CFCs. The extensive use of refrigeration assures adequate food supplies and helps prevent or retard microbial, physiological and chemical changes in food products that lead to spoilage. In addition, refrigeration plays a very significant role in the manufacture and storage of lifesaving pharmaceuticals and medical supplies, including blood, tissue samples and drugs such as penicillin in hospitals and public health facilities.

Air Conditioning Uses

Air conditioning has become essential in providing adequate environmental control, thermal comfort and health in most buildings. There are also extensive process and manufacturing uses of air conditioning for temperature control. Virtually all air conditioning systems use CFCs, primarily R-11, R-12, and R-22 as a refrigerant. The applications of these systems provide the basis for comfort cooling for millions of homes by room and central air conditioners, and the environmental control in commercial buildings such as offices, stores, schools, hospitals, and hotels. ASHRAE has conducted extensive research in the fields of human comfort, documenting the beneficial effects of air conditioning in reducing heat stress and improving health, safety and productivity. In addition, photographic materials, electronic components, computer operations, laboratories clean spaces and telecommunications could not function without the environmental control provided by air conditioning. Finally, the economic development of the states in the sunbelt would not have occurred, nor could it be sustained without air conditioning.

Insulation Uses

Rigid, closed cell foam made with CFCs is used extensively in refrigeration and air conditioning applications for thermal insulation. Rigid foam produced by using CFC-11 as a blowing agent, results in a very effective insulating material with low thermal conductivity. Such foams are used for insulation in household refrigerators and freezers, commercial refrigeration displays and storage facilities, refrigerated rail cars, delivery trucks and truck trailers, in addition to commercial and residential buildings. Foam insulation made with CFC-11 has superior characteristics of energy efficiency, weight and cost, not achievable with substitute blowing agents.

Alternate Refrigerants

Interchanging one refrigerant for another in existing equipment creates numerous problems bearing on equipment safety, performance and reliability. One reason is that the equipment design has been optimized after years of engineering development and field experience. Besides, the present refrigerants have evolved over a span of fifty years of research and have the unique combination of properties of thermodynamic efficiency, low flammability and low toxicity. Incorporation of any new refrigerant in new designs requires a long-term evaluation of these characteristics.

The National Academy of Sciences alludes to the possiblity of converting the entire refrigeration and air conditioning industry to the use of refrigerants not containing chlorine. However, it also acknowledges that there are, at present, no suitable replacements for chlorofluorocarbon refrigerants.

Ammonia, which is free of chlorine is used in a number of industrial applications. However, it is toxic and would not be acceptable in residential use and in places of public gathering. Older refrigerants such as sulphur dioxide (toxic), methyl chloride (toxic and flammable), and propane (flammable) are also unacceptable.

Other halocarbons containing hydrogen, or fluorocarbons not containing chlorine, have been suggested as possible replacements for CFC 11 and 12, but none have been found to be satisfactory. Some are too toxic, some are flammable and others do not have suitable thermodynamic properties. One potential candidate is R-134a, $CH_2 FCF_3$. However, in spite of intensive efforts, "there is no currently known practical manufacturing process for this material, and it has not been fully tested for toxicity" (NAS - p. 161). Work is continuing on both problems. It is estimated that ten years or more will be needed to produce commercial quantities of R-134a, assuming a manufacturing process is discovered and toxicity testing is favorable.

Economic Impacts

The economic impacts of various CFC uses and methods of regulating CFC emissions are discussed in detail by the Rand Corporation. The dollar costs estimated by Rand vary with the type of regulation proposed, but they are all very large.

The economic consequences of regulation are complex and reach beyond those immediately foreseeable. Rand discusses "transfer payments" such as taxes, cost of permits, higher CFC prices, etc. They say "for the firms that pay them, transfer payments are an expense that will be reflected in higher prices to the consumer and a greater risk of plant closure and worker unemployment" (Rand Report - p. 17). These consequences would be of grave concern to those directly affected -- including job-holders in the refrigeration and air conditioning industry and those affected by higher costs. Rand estimates tnat "under an uncompensated economic incentives policy, cumulative transfer payments would be very large, ranging upward from $1.5 billion for the least costly benchmark-equivalent policy" (Rand Report - p. 18)

As envisioned by the EPA, limitation in CFC production by whatever method would lead to ever-increasing costs to the user as shortages develop. Industries unable to support these higher costs would fail or perhaps find less efficient substitutes. Presumably, essential air conditioning and refrigeration applications would survive regardless of the cost, but with severe adverse effects on both foreign and domestic markets, Marginal applications would disappear.

Regulation of any type is bound to cause tremendous upheavals and dislocations in the lives of those associated with refrigeration and air conditioning as well as the general public -- all based on a theory not supported by present facts or scientific interpretations.

Energy Impacts

In addition to the direct economic impact of regulating CFCs, an energy penalty, of considerable magnitude, would be a further burden for this country. The estimated net energy penalty is equivalent to 50-billion gallons of fuel for the first decade following a ban on chlorofluorocarbons (Battelle Report). This staggering fuel cost is based on refrigeration, air conditioning, food freezing, and associated insulation. Other applications of CFCs have not been included.

If, instead of a complete ban, CFC production and usage is restricted, the energy penalty would be less but would still have an adverse and serious impact on an already critical energy problem.

REGULATORY ISSUES

The Environmental Protection Agency (EPA) has stated in its Advance Notice of Proposed Rulemaking that "ozone depletion truly is a global problem." (45 FR 66728). Further, the EPA notice shows that CFC use is roughly divided equally among the United States, the European Economic Community (EEC) and other nations, including Japan. Regardless of point of emission, tropospheric mixing results in worldwide distribution of CFCs with only some small differences in concentration. Hence no single nation can unilaterally control ozone depletion.

Given these facts, EPA has surmised that:

1) If the United States adopts a "wait and see" strategy, the great majority of other CFC-using nations will follow suit.

2) If the United States adopts a "no-growth" strategy, limiting production of CFCs to present levels, it will signal other nations that the problem is perceived as being serious.

3) If the United States adopts a strategy of "substantial emissions reduction," the EPA conjectures that this would weaken international action of the same magnitude by other nations.

EPA concludes that a "no-growth" strategy, limiting U.S. production to present levels, is the best course of action at present. EPA proposes that this action would be followed by a "significant emissions reduction" policy if international conditions warrant.

In the view of ASHRAE, the EPA conclusions are inconsistent and directly at odds with recommendations of the European Economic Community Commission established to study the halocarbon issues. The EEC report on CFCs concludes that current models developed to approximate the effects of CFCs on ozone are "simplistic" and "cannot fully describe the behavior of the atmosphere and its minority constituent parts." (CRP, 9/5/81). The report predicts that an accurate scientific model will not be developed for at least five years, making it impossible for the EEC to take valid action on CFC control before then. Moreover, based on the U.K. analysis, the EEC has concluded that a delay of five years before any decision is taken on CFCs is acceptable. The EPA belief that other nations will follow the U.S. lead of "no-growth" is obviously erroneous. EEC has chosen the so-called "wait and see" strategy despite the announced position of the EPA.

Parenthetically, the "wait and see" strategy is an erroneous terminology. Extensive research efforts already under way, will in the next few years provide "an explosion of new results in stratospheric trace species measurements." These data will not only improve our understanding of the stratospheric ozone balance, but will also provide scientific tests for validation of atmospheric models upon which to base future decisions. (U.K. Report - paragraph 104).

ASHRAE concludes that the EPA is unwittingly recommending a unilateral course of action for the United States. Adoption of either the "no-growth" or "substantial reduction" strategy will result in severe economic penalties to the air conditioning and refrigeration applications domestically and will sorely handicap the United States in its competition for international markets.

ASHRAE ACTIONS

In consideration of the major world-wide impact of the halocarbon issue and its effect on the professions, the products and the members of our technical society, ASHRAE is committing its resources to assist in arriving at an effective and wise course of action. The following specific activities are underway or are planned and scheduled for the near future.

1. Utilizing the breadth and depth of talent available in the Technical Committees of the Society, ASHRAE will develop guidelines for addressing many of the questions related to the halocarbon usage by the refrigeration and air conditioning industry. Applications both as working fluids and as blowing agents for thermal insulation will be considered. Guidelines will be developed to minimize inadvertent loss of CFC during manufacture and servicing of products. An ASHRAE Task Group on Halocarbon Emission Control has already been appointed to address three subjects: leakage of halocarbons from equipment, loss of halocarbons during servicing of equipment and the loss from discarded products at the end of a useful life. Forums on "service problems on CFC emissions control" and on "refrigerant disposal" are planned for the two 1981

ASHRAE meetings. ASHRAE will utilize its national and international organizational structure to disseminate information from these activities and to provide guidelines for industry practices.

2. ASHRAE is unique among professional technical societies in that for many years it has conducted a Research and Technical Program in Technologies important to the membership. The subjects addressed over a broad range of topics including not only air conditioning, heating and refrigeration practices, but also such subjects as thermodynamics, human comfort and food preservation and storage. ASHRAE itself does not maintain facilities and a staff to carry out research and development activities; rather the society utilizes experienced members and staff to allocate funds and oversee research that is sponsored at leading universities and other established research facilities.

In view of the importance of the halocarbon issue to the nation and to society, ASHRAE will actively encourage research and as appropriate will spend a portion of ASHRAE funds for projects related to this subject. Major emphasis will be placed on those aspects of halocarbon usage that relate directly to applications involving ASHRAE. Examples of topics which would receive serious consideration for funding are:

- review of alternate materials for refrigeration and thermal insulation;
- relative stabilities of halocarbons in vapor compression systems and upon release to the atmosphere;
- effect of substitution of one halocarbon by another on efficiency and capacity of equipment;

- commercial availability and economics of producing alternate working fluids;
- new methods for recovering halocarbons for air conditioning and refrigeration products at the end of a useful life.

3. ASHRAE is an international society in that is has over 4,000 active members in 118 foreign countries. Special interests of these members are represented by the International Activities Committee, one of the Standing Committees of the Soceity. As further evidence of ASHRAE's world-wide leadership role, ASHRAE maintains the Office of the Secretariat for the U.S. National Committee of the International Institute of Refrigeration. Through these international connections, the society and its members have developed a close working relationship with the professionals and industries related to air conditioning and refrigeration around the world.

   ASHRAE will avail itself of these international connections to meld a common position and course of action related to the halocarbon issue. As previously stated, the ozone depletion hypothesis poses a problem of global dimensions; a problem that cannot be resolved by unilateral action on the part of a single nation. The prudent course of action, and the course that ASHRAE intends to follow, involves seeking an international consensus that best serves the interests and viewpoints of all parties.

4. ASHRAE strongly recommends that scientific studies related to the ozone depletion hypothesis be continued and accelerated. It is recognized that modeling and simulation are the basic tools for predicting complex physical and chemical behavior in the upper atmosphere, and this work necessarily must continue. However, in view of the urgency for obtaining the earliest possible direct evidence for or against ozone depletion, we urge that direct measurement of ozone concentrations, of UV radiation and of primary chemical species be given highest priority.

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CMA

CHEMICAL MANUFACTURERS ASSOCIATION

ROBERT A. ROLAND
President

August 3, 1981

The Honorable Slade Gorton
Chairman
Subcommittee on Toxic Substances
and Environemntal Oversight
Committee on Environment and
Public Works
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

At the July 23, 1981 hearing regarding chlorofluorocarbons before your Subcommittee on Toxic Substances and Environmental Oversight, a witness for the Alliance for Responsible CFC Policy offered to provide scientific comments of the Fluorocarbon Program Panel of the Chemical Manufacturers Association. At this time, you indicated that these comments should be submitted for inclusion in the hearing record. We are pleased, therefore, to transmit this letter and attachments pursuant to your request.

The Chemical Manufacturers Association (CMA, formerly the Manufacturing Chemists Association) is a non-profit trade association whose 184 United States member companies produce more than 90 percent of this country's basic industrial chemicals. As part of the CMA structure, a Fluorocarbon Research Program was intitiated in 1972.

This program is sponsored by 19 CFC producers headquartered in nine countries, and representing approximately 95 percent of the free world production of CFCs. The Fluorocarbon Program Panel (FPP), comprised of representatives of the 19 producers, directs the research program by authorizing, monitoring and guiding the scientific studies. Independent expert investigators conduct the research on possible environmental effects of CFCs released to the atmosphere. The charter of the FPP states:

> "The Fluorocarbon Program Panel will conduct a research program in atmospheric sciences to determine the effects, if any, of fluorocarbons on the environment and to maintain scientific exchange in interpretation of data with government agencies, universities and the public."

Therefore, the activities of FPP are limited to determining, assessing, and disclosing scientific facts. All research results must be made public. Investigators are urged to publish their results, and any patentable discoveries are dedicated to the public.

In addition to this letter, three attachments are hereby transmitted:

Attachment I - Executive Summary of Key Points by the CMA Fluorocarbon Program Panel Regarding the CFC/Ozone Depletion Theory.

Attachment II - Assessment of the Science Relating to the CFC/Ozone Depletion Theory.

Attachment III - Comments on Testimony Presented July 23, 1981 before the U.S. Senate Subcommittee on Toxic Substances and Environmental Oversight regarding Chlorofluorocarbons.

We appreciate the opportunity to provide scientific comment relative to the Chlorofluorocarbon/Ozone Depletion Theory, and request that this letter and three attachments be made a part of the formal record of the July 23 hearing.

Sincerely,

Robert A. Roland
President

Attachments: I, II & III

Attachment I

EXECUTIVE SUMMARY
KEY POINTS BY THE CMA FLUOROCARBON PROGRAM PANEL REGARDING THE CFC/OZONE DEPLETION THEORY

- More research is needed to improve knowledge and understanding of the effects, if any, of man's activities on the ozone layer. The theory is neither proved nor disproved at this time.

- There is time to do the research at minimal risk. Ozone depletion by CFCs is theorized to be a slow, gradual process. For example, in a hypothetical scenario, if a 50 percent reduction in U.S. CFC production were delayed 10 years, the maximum difference in calculated ozone depletion would be only 0.1 percent, if the current theory were true and steady state values of ozone depletion would be the same in either case.

- Ozone depletion has not been observed. If anything, ozone levels increased during the decade of the 1970s.

- If a small trend (depletion) in ozone were to occur, i.e., 1.5 percent per decade, it would be detected by ozone trend analysis. We have an early warning system to alert us to any problem actually developing.

- Model calculations are highly uncertain and no method exists to test their predictive reliability at this time. Only additional research will improve this situation.

- Most modelers calculate the effects of CFCs on the ozone layer in isolation, as if nothing else affected ozone. When other changes in the atmosphere are included, the combined effect is to reduce calculated ozone depletion.

- Models now calculate 5 percent ozone depletion at steady state, more than 100 years into the future. In 1978, models calculated about 18-19 percent ozone depletion. The reduction was the result of new information acquired in the 2-year period since 1979.

Attachment II

STATEMENT OF

THE FLUOROCARBON PROGRAM PANEL
OF THE
CHEMICAL MANUFACTURERS ASSOCIATION

In 1972, representatives of the major CFC manufacturers of the United States, Europe, Japan and Canada formed an organization to investigate the possible environmental consequences of the release of CFCs to the atmosphere. It should be noted that at that time, CFCs had not been linked to any environmental problem -- in theory or in fact. The program was initiated almost two years before Drs. Rowland and Molina published the CFC/Ozone Depletion Theory. It was decided that the best approach was to fund expert investigators in university, government or independent laboratories to carry out the research with the industry organization directing, monitoring and guiding the scientific studies.

The original studies of the Fluorocarbon Program Panel (FPP) concentrated on possible effects of CFCs on the lower atmosphere such as smog formation and plant effects. The results of the early studies showed that:

- CFC-11 and 12 were each present in the lower atmosphere at concentrations of about 50-100 parts per trillion by volume;
- they were not decomposed by sunlight in the lower atmosphere and thus did not contribute to smog formation;
- they did decompose under shortwave ultraviolet radiation that would be encountered in the upper atmosphere; and,
- they had no injurious effects on plants within the limits of the experiments.

Shortly after these results became available, Molina and Rowland [1974] suggested that CFCs may deplete the ozone layer. As a result, the industry program was expanded to fund research which would reduce or eliminate the many uncertainties related to the suggested effects of CFCs on the ozone layer.

The program has committed about $10 million to date. The research budget for 1981 is $1.8 million. These numbers do not include the numerous studies conducted by the individual participating companies or salaries and expenses of panel members. We estimate the program costs would about double if they were included.

The FPP has reviewed more than 370 research proposals and has funded more than 70 investigators worldwide, who are acknowledged experts in their fields of study. We have completed 115 projects with about 33 currently active. The program has contributed more than 160 original publications to the scientific literature in the area of atmospheric science and related subjects.

Although the scope of our research activities is smaller than that of the National Aeronautics and Space Administration (NASA), through programs of mutual interest, the FPP maintains close liaison and cooperation with NASA, the National Oceanic and Atmospheric Administration, the National Bureau of Standards, the National Center for Atmospheric Research, the Department of Transportation, the National Science Foundation, and the scientific activities of the Environmental Protection Agency. FPP has funded or co-funded substantial research in several of these government laboratories.

The Panel funds research in the areas of ozone trend analysis, chemistry, computer modeling, atmospheric measurements, and the atmospheric lifetimes of CFCs -- all directed to a better understanding of the ozone depletion theory. Research investigators are urged to publish all of their significant findings regardless of the impact on the theory.

In more detail, the FPP areas of research are as follows:

- Ozone trend analysis is a statistical method which analyzes actual ozone measurements. The results indicate there has been no ozone depletion to date and perhaps, more importantly, the method has shown that very small long-term changes in ozone could be detected, if they were to occur.

- The Panel funds laboratory studies on the rates of important chemical reactions and their products. A thorough understanding of atmospheric chemistry is essential as these chemical reaction rates are used as input data for the computer models being used to calculate theoretical ozone depletion.

- Our research program has developed computer simulations of the atmosphere, called models, in an attempt to better understand their usefulness and limitations. They are essential tools to better understand stratospheric chemistry. They are used to guide our research program into the most productive areas and to carry out sensitivity tests on new model input data, e.g., new chemistry, rates of reactions, etc.

- Finally, our program in atmospheric measurements funds investigators to measure chemical species in the atmosphere that are important in the proposed chemical schemes for ozone depletion, and to develop new methods to measure these species. These measurements serve as a vital check on the ability of computer models to simulate the present day atmosphere. We also have had an experiment in progress for several years to measure the lifetimes of CFC-11 and CFC-12 in the lower atmosphere because these lifetimes determine the amount of chlorine introduced into the stratosphere (upper atmosphere) by these compounds. Only chlorine that reaches the stratosphere is capable of reacting with the ozone layer.

At this point, it would be helpful to describe the earth's atmosphere and give a brief review of the ozone depletion theory.

The earth's atmosphere to an altitude of about 50 km (30 miles) is divided into two regions -- the troposphere (lower atmosphere) and the stratosphere (upper atmosphere). The two regions are separated by the tropopause, which varies in altitude from about 8 km (5 miles) at the poles to about 16 km (10 miles) at tropical latitudes. Ozone (O_3) is the most important trace constituent of the stratosphere. It is formed predominately at altitudes between 25 km (15 miles) and 35 km (21 miles) in the tropics, where short wavelength solar radiation dissociates molecular oxygen into oxygen atoms which, in turn, combine with molecular oxygen to form ozone (Reactions 1 & 2).

O_2 + hν (solar radiation) → O + O (1)

2 [O + O_2 + M*] → 2 O_3 + 2M (2)

Net: 3 O_2 → 2 O_3

*M is any other molecule

Although stratospheric ozone is produced mainly in the tropics, highest ozone concentrations are found in polar regions at altitudes of about 15 km (9 miles) as a result of air motions in the stratosphere. The production of ozone is currently assumed to be relatively insensitive to man's activities.

Ozone strongly absorbs solar radiation in the longer wavelength radiation region 240-320 nm (Reaction 3).

O_3 + hν → O_2 + O (3)

It is this absorption that shields the earth from ultraviolet radiation. In this process, the net amount of ozone is not changed since nearly all the oxygen atoms produced recombine with molecular oxygen to produce more ozone (Reaction 2).

Although the reactions just described are the predominant stratospheric production process for ozone, several destruction processes exist. The amount of ozone in the stratosphere is maintained by a dynamic balance between production processes and destruction processes. The most important destruction process is thought to be a catalytic cycle involving nitric oxide (NO) and nitrogen dioxide (NO_2).

NO + O_3 → NO_2 + O_2 (4)

NO_2 + O → NO + O_2 (5)

Net: O + O_3 → 2 O_2

Because jet aircraft engines exhaust oxides of nitrogen, concern existed in the early 1970s that supersonic transports flying in the stratosphere would deplete the ozone layer [Johnston, 1971].

Stolarski and Cicerone [1974] and Wofsy and McElroy [1974] suggested that the catalytic chlorine cycle may be a destruction process for stratospheric ozone,

$$Cl + O_3 \rightarrow ClO + O_2 \qquad (6)$$
$$ClO + O \rightarrow Cl + O_2 \qquad (7)$$

$$\text{Net:} \quad O + O_3 \rightarrow 2\ O_2$$

but only natural sources of chlorine, e.g., volcanoes, were considered. In Reaction 6, Cl reacts with O_3, but Cl is reformed in Reaction 7, allowing Reaction 6 to occur again. In theory, this cycle can repeat many times. In fact, if it does not repeat many thousands of times, the process will not significantly deplete ozone in the stratosphere. However, the number of times Cl goes round the cycle has never been measured in the stratosphere -- directly or indirectly. The same year, Molina and Rowland [1974] proposed that chlorofluorocarbons (CFCs) provide a significant chlorine input to the stratosphere and thus deplete the ozone layer -- the CFC/Ozone Depletion Theory. They suggested that:

- CFCs have a long atmospheric lifetime with no significant destruction mechanism in the lower atmosphere (troposphere).
- CFCs diffuse to the stratosphere.
- CFCs are decomposed in the stratosphere by ultraviolet radiation to produce chlorine atoms.
- Chlorine atoms gradually reduce the concentration of ozone in a catalytic cycle (Reactions 6 & 7).

FPP would now like to present an assessment of the scientific facts that relate to the ozone depletion theory by discussing three questions:

- What estimates can we make about the effects of CFCs on the ozone layer?
- How reliable are the estimates?
- What do measurements tell us about the ozone layer?

What Estimates Can We Make About the Effects of CFCs on the Ozone Layer?

If the ozone depletion theory were true, CFCs could have significant effects on the ozone layer only decades into the future. Ozone depletion by CFCs is theorized to be a slow, gradual process. As a result, scientists have tried to estimate the magnitude of the effects by use of atmospheric models. These models are really complicated computer programs that attempt to simulate mathematically the atmosphere of the earth. The models use chemical and photochemical reaction rates as input data and largely ignore detailed atmospheric dynamics.

The models have been used to calculate the theoretical effects of continued release of CFCs to the atmosphere. Based on model calculations, the NAS report [1979] gave a value of 18.6 percent ozone depletion at steady state (a hundred or more years into the future). However, ever since the theory was first announced, the values of model calculated future ozone depletion have changed -- both up and down -- as new scientific information has become available. As an example, when the most recent revisions in chemistry are incorporated in the models, they calculate a 5-7 percent ozone depletion at steady-state rather than the 18.6 percent value reported in 1979 by the NAS.

It is important to realize that the atmospheric models now available cannot realistically predict the future and, therefore, ozone depletion figures calculated by them should not be taken as truth. Models may, however, be used to calculate the consequences of a set of assumptions about the future. But the results are only as good as: (1) the model's completeness, (2) the accuracy of the input data, and (3) the approximations used. Because of these limitations, the "future", as calculated in atmospheric models, may bear little resemblance to the actual future.

Models assume that all inputs to the stratosphere remain constant except the variables under consideration. However, examples of departure from the CFC model assumptions are known: CO_2 is increasing; N_2O is thought to be increasing; other chlorine-containing compounds are possibly increasing; natural events are poorly quantified and may have unpredictable long-term effects; and aircraft and space shuttle fleets are likely to continue injecting increasing amounts of reactive emissions into the atmosphere. In short, models calculate only what would happen in a simplified idealized atmosphere -- an atmosphere which does not exist in the real world.

The next question is:

How Reliable Are the Estimates?

In theory, a complete model of the earth's atmosphere in three dimensions (altitude, latitude, and longitude) could be constructed to include all known chemistry, atmospheric dynamics (air motions), seasonal effects, diurnal effects, etc. However, such a model will not exist in the foreseeable future because:

- The required input data are not available.
- Construction of the model would be an enormous task -- perhaps an impossible one.
- Even today's most powerful computer would be inadequate to deal with such a complex model in any reasonable period of time.

Therefore, models that describe the earth's atmosphere in only one dimension (altitude) have been most widely used to calculate future potential ozone depletion. However, even these models incorporate many simplifications and assumptions in their construction in order to make them manageable and to conserve valuable computer time. The models mainly use chemical reaction rates as input data and describe the motion of chemical species only in the vertical direction.

A number of major uncertainties relate to these model calculations:

- The rates of many chemical reactions which are used in the models have not been measured under the range of conditions of stratospheric temperatures and pressures.

- The products of many chemical reactions in the model have been assumed but have not been determined -- under any conditions.

- It is assumed that the entire chlorine content of CFC-11 and CFC-12 released into the lower atmosphere reaches the stratosphere and that all this chlorine depletes ozone.

- The movement of chemical species (transport) in the models is fixed rather arbitrarily.

- The uncertainty limits of model calculations are subjective estimates. They are not definable objectively.

- The models do not calculate accurately the present-day atmosphere.

- The predictive reliability of atmospheric models is unknown.

Nonetheless, the models are useful to guide research. As an example, a model can be used to calculate a "standard" scenario with some experimental change in the chemical input data. If the results are significantly different from those obtained using the unchanged chemical data, the new chemistry may be important and worth further investigation.

Models can also be applied to the problem of what might happen over a relatively short time into the future. As an example, current calculations indicate that total ozone would not be affected significantly over the next 10-20 years by man-made changes in the atmosphere, even if the current ozone depletion theory proves to be correct.

Another use of the models is to calculate the difference in ozone depletion between two or more hypothetical CFC emission reduction scenarios. In other words, the models can be used to calculate the theoretical effect of various regulatory scenarios. As an example, a recent model calculation compared a scenario in which U.S. CFC present-day emissions were reduced by 50 percent in 1980, with a second scenario which assumed that present-day U.S. emissions continued to 1990 and were then reduced by 50 percent. The difference in calculated potential ozone depletion between these two scenarios (the effect of 1980 regulation vs. a postponement to 1990) is always very small at any time in the future. The difference slowly increases to only 0.09 percent ozone depletion by about 2015, and slowly decreases thereafter.

However, all the above uses of the models are diagnostic -- "what if" -- calculations. They are not adequate simulations of the present real atmosphere or of any likely future atmosphere. The predictive reliability of atmospheric models is unknown, and for now, no good way exists to test it. At any given time, our knowledge of atmospheric sciences and effects on the ozone layer is the "best" to that date. Using this knowledge and ignoring all man-made influences other than CFCs, the computer calculates a theoretical future CFC ozone depletion. But, as new information has become available, calculated ozone depletion has either increased or decreased -- yet the high degree of uncertainty of the value has remained.

As the research programs now in progress provide new knowledge and insight on atmospheric chemistry and dynamics, the uncertainties will be reduced and ultimately bring us to a level of knowledge where there can be no reasonable doubt about man's influences on the ozone layer. And, fortunately, as those studies continue, we can measure and monitor the ozone layer to ensure that ozone depletion is not occurring.

And that leads to the third question:

What Do Measurements Tell Us About the Ozone Layer?

Ozone has been measured at monitoring stations and by balloons, rockets, and satellites around the globe for a relatively long time. Some of the ground-based measurements began in 1926. At the beginning of the International Geophysical Year (1957) approximately 35 stations were taking measurements. This peaked to nearly 100 stations in the mid-60s and about 75 stations now operate. The bulk of the measurements made at these stations are called "total column" since they measure the number of ozone molecules in a vertical column of air extending from the earth's surface to the upper limits of the earth's atmosphere. They show that ozone levels fluctuate with the seasons, latitude, the amount of energy received from the sun, and other natural phenomena. However, the overall behaviour of the ozone layer is not yet understood completely.

Nevertheless, the most important aspect of these ozone measurements to date is that no ozone depletion has been observed. Two atmospheric scientists, Angel and Korshover [1980] reported:

> "The 1979 data suggest the highest global total-ozone value since 1970, or a value a significant 2 percent above average."

In their studies of the ozone layer, meteorologists have looked for trends, i.e., systematic changes in ozone levels over a relatively long period of time. The detection threshold of a trend is a critical value. This value represents the smallest change in ozone levels that would be judged statistically significant (expressed as percent) from any cause that can be detected in an arbitrary time period -- usually a decade. If the threshold were large, then a large change in ozone could go undetected. On the other hand, if the threshold were small, small trends in ozone could be detected.

Beginning about the mid-1970s, statisticians began to analyze ozone measurements by a method that has become known as "ozone trend analysis." By this method, the trend in actual ozone concentrations and the threshold limits to detect a trend are obtained directly from analysis of the historical record of ozone measurements. These studies all agree that in the 1970s, ozone depletion did not occur but, rather, ozone levels increased slightly.

One study [Reinsel et.al., 1980] showed that the threshold to detect a true trend from any cause in the 1970s was ± 1.3 percent per decade. In a somewhat different study [Bloomfield et.al., 1980], it was shown that any trend that does not exceed ± 2.0 percent per decade may be attributed to natural variation or, stated another way, if a trend were to exceed 2.0 percent per decade, a man-made effect would be suspected.

This ozone trend analysis provides an early warning system since any trend exceeding 1.3 percent per decade would be judged as a real change in O_3, and a trend exceeding 2.0 percent per decade might be attributed to man-made effects. In addition, the method will become more sensitive over time as additional years of ozone measurements are analyzed, i.e., a smaller and smaller trend could be detected in future years.

Ozone trend analysis can tell us what happened to ozone levels in the past and what is happening to ozone levels at present. It can monitor all effects on the ozone layer -- known and unknown -- and give a picture as to what is occurring in the real world. Its results are completely independent of the computer models and their limitations.

But that is not to say models are unimportant since they provide a possible means to understand the ozone layer and the effects of man's activities on it. More research in chemistry, atmospheric measurements, and modeling itself is needed to help achieve that understanding. If we take time to do the research, we incur a risk. But the computer models have estimated that risk and found it to be very small, even if the theory is true. In addition, ozone trend analysis tells us that there is no evidence of ozone depletion to date and ozone trend analysis can be used to monitor ozone levels continually during the research period. In the event a problem should develop, changes in the ozone can be detected long before any crisis occurs. In short, we now are able to detect what, if anything, is happening to ozone and we are able to monitor what might happen to ozone in the future. Therefore, in the judgement of the FPP, the results of scientific studies performed to date already provide an adequate degree of protection to mankind while further research progresses.

7/31/81

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Attachment III

COMMENTS OF

THE FLUOROCARBON PROGRAM PANEL
OF THE
CHEMICAL MANUFACTURERS ASSOCIATION

Representatives of the Chemical Manufacturers Association Fluorocarbon Program Panel (FPP) were present at the Senate Environment and Public Works Committee's subcommittee hearing on the Chlorofluorocarbon/Ozone Depletion Theory. Oral statements about the theory were presented at the hearing. FPP's comments on those statements are given below.

Experimental Evidence Regarding the Ozone Depletion Theory

A number of the oral statements before the Subcommittee on Toxic Substances and Environmental Oversight discussed the specific steps involved in the Chlorofluorocarbon/Ozone theory and the status of their verification. Release of the chemicals and their existence in the lower and upper atmosphere are well documented. While no mechanisms of decomposition in the lower atmosphere have been experimentally verified, a number of studies are still in progress and the possibility of a small but significant loss process is consistent with the data. While the data are also consistent with the absence of a process for destruction in the lower atmosphere, they do not rule out such a process and the possibility for reduction in calculated depletion remains viable - hence the continued study by a number of investigators.

Release of chlorine atoms by photolytic destruction of CFCs in the stratosphere is quite well understood. Budget calculations based on known man-made chlorine releases at ground level and measured concentrations of chlorine in the stratosphere are consistent, but are equally consistent with the hypothesis that there remain both unidentified sources of chlorine and errors in current model estimates of chlorine removal rate. Thus again, consistency is a useful test for obvious errors, but uncertainties, particularly in the measurements, prevent its use for verification of the theory as a whole. The reproducibility of total chlorine measurements is uncertain by approximately 20 percent, and the accuracy of the measurements is even more uncertain.

The chemistry of chlorine species and related atmospheric constituents is an important aspect of the theory. The existence of reactions by which chlorine can remove ozone has indeed been verified. However, as stated by several witnesses, chlorine and chlorine monoxide also participate in other reactions, and the extent to which ozone can be removed remains in doubt. Although the chemistry at high altitudes was referred to as "simpler", and most of the recent changes in our understanding have been in the chemistry of the lower stratosphere, two points deserve mention. First, two-dimensional models show that chlorine added to the lower stratosphere can increase the local ozone concentration. The extent to which these processes take place remains a major issue in current chemistry research. Second, the lack of recent changes related to the chemistry of the upper stratosphere remains far from a confirmation of the present chemistry. The major missing link is any experimental demonstration of a reduction in the high altitude ozone which is consistent with the theory. In fact, Umkehr measurements suggest an ozone increase in the region inconsistent with the calculated decrease.

The major available test of chemistry is a comparison of model calculations with measurements of the amounts of various chemicals throughout the stratosphere. The measurements are limited and confounded by uncertainties and the natural variability of the stratosphere. As far as they go, the comparisons demonstrated reasonable agreement for most chemical species. However, such agreement has been fortuitous in past model calculations. For some well-measured species, agreement between measurements and model calculations is not a sensitive test of the adequacy of the chemical scheme. In addition, what must be remembered is that such comparisons say little or nothing about the models' ability to predict the result of changes in the atmosphere. This aspect remains untested. While this point was not mentioned at the hearing, it is supported in the oral testimony.

Ozone Depletion Calculations

The amount of depletion calculated by models for continued constant release of CFCs 11 and 12 (at mid-1970s levels) into an otherwise unchanged atmosphere were variously presented as 5-7 percent, 5-8 percent and 5-10 percent. For some unstated choice of increasing release, a value of 20 percent was projected for the middle of the next century. Some words of explanation are in order.

For the most up-to-date chemistry, 1-D and 2-D models give values of 5-7 percent ozone depletion at steady state for continued constant release. Postulated (but not recommended by NASA) changes in the chemistry could lead to larger calculated numbers. Steady state would not occur for over one hundred years. (True steady state is achieved only after several hundred years in models, but the majority of the depletion has taken place after about 150 years). Only unrealistic and speculative projections of a rapid increase in production could possibly lead to a calculated value of 20 percent during the next century. Capacity for such production is simply not available.

In any event, these figures seem to ignore the fact that ozone measurements would detect any significant depletion of the ozone layer long before the crisis situation implied by these values could actually occur. This "early warning system", based on ozone trend analysis, can detect small changes in ozone. The analysis becomes more sensitive with time, i.e., smaller changes can be detected as more ozone measurements are recorded.

Another important aspect of any estimate of ozone depletion is the reliability of the estimate. How certain or uncertain are we that the calculated or "predicted" depletion will actually occur in the real world? FPP believes that the uncertainty is very large and can be reduced only by additional research studies. As was pointed out at the hearings, an active research program should provide the information needed in 5-10 years to determine with a reasonable degree of certainty to what extent, if any, CFCs deplete stratospheric ozone. NASA, FAA, NOAA, NBS, EPA and agencies of many foreign governments are conducting research toward this end. FPP activities are coordinated with these programs and, in fact, FPP funds or co-funds essential parts of the effort.

Thus, although much of the available evidence is consistent with the theory, it is also consistent with quite different conclusions. To repeat a point made by one of the scientists, "our scientific understanding of the stratosphere is extremely immature. We have but a rudimentary grasp of the relationship between global transport processes, radiation, and photochemistry." Yet it is precisely this relationship which controls the delicate balance between production and destruction of ozone.

The key question - Will increased concentrations of chlorine atoms in the stratosphere result in decreased concentrations of ozone? - has yet to be answered.

Measurements of Ozone

While the ground based and satellite measurements of total ozone and ozone at various altitudes were discussed thoroughly in oral testimony, again there was some confusion regarding numbers. All statistical studies of ground-based total ozone measurements have found slight although not statistically significant increases in ozone. Thus while these analyses are consistent with calculations of less than 1 percent ozone depletion, they are also consistent with increases in ozone of over 2 percent. Therefore, they tell us very little about the model results, except that there has been no large depletion such as that "predicted" by the NAS in 1979.

The uncertainties in these analyzed total ozone trends was given variously as 1.3 percent, 1.2-2.0 percent, 2.5 percent and 5 percent. The various statisticians have maintained on the basis of their individual studies that small trends ranging from 1.3 to 2.0 percent could be detected. Some allowance for other unusual effects would increase this value to as much as 2.5 percent. However, the latest studies indicate that trends of well below the 5 percent mentioned in one statement could be easily seen.

Because current models predict a relatively slow growth in calculated depletion with time, ozone measurements are unlikely to give evidence of a trend in the near future. However, this is a very positive result. The models also indicate that additional depletion beyond the cessation of CFC production is small compared to the amount of depletion at the time of cessation. Thus halting CFC production when 2 percent depletion has been detected would lead to less than 0.5 percent additional depletion before a gradual recovery begins. Even with current models, a ten-year delay in a 50 percent reduction of total U.S. production leads to only about 0.1 percent difference in maximum depletion. Thus the "banking" (or delayed release) of fluorocarbons in some applications, and the slow transport to the stratosphere serve to spread out any calculated effects. Although a trend is slow in developing, this does not mean that it will become very large. If and when regulation is needed it can be applied.

The major value of ozone trend analysis is its utility as a warning system to detect any developing trend, not as a means of proving or disproving the theory. Thus the NASA, EPA and FPP research along with that of other groups can proceed either until the models are brought to a satisfactory state of perfection or until the (still very small!) trend is observed.

With the current detection system, the steady state values of ozone depletion are not the real concern. They merely provide a reference point regarding the magnitude of the potential problem. Any detection of depletion at the far lower levels of 1.2, 1.3, 2.0 or even 2.5 percent could be followed by the appropriate action to prevent significant further depletion. Thus there is little danger of 20 percent or 10 percent depletion actually occurring in the real world, with or without immediate action. In fact, since ozone trend analysis studies indicate that the detection sensitivity for trends improves as the data record increases, one can expect continued reductions in detection limits over the next several years.

Measurements of ozone in the upper stratosphere may provide a still more sensitive test for the presence of ozone depletion. The published study of so-called Umkehr measurements of ozone from the ground which was discussed in oral testimony shows an increase in ozone inconsistent with calculated decreases of 6 percent at 40 km altitude. A less detailed study of satellite measurements made in only two years by two different satellites was mentioned indirectly by another of the participants. The latter study indicates a depletion consistent with model calculations for CFCs but it is the only study to do so, and does so only by correcting arbitrarily for solar cycle effects. The assumed correction is inconsistent with calculations of the solar cycle effect from the same models. This inconsistency, along with the lack of cross calibration between the two somewhat different satellite instruments involved, considerably weakens this study opposite the greater detail and larger data base of the Umkehr study. Thus even the "simpler" situation at 40 km is so far not confirmed by observations.

Summary

The majority of oral testimony referred to the "consistency" of available experimental data with the principal details of the Chlorofluorocarbon/Ozone Depletion Theory. However, equally well demonstrated were the major uncertainties on most aspects of the theory. Due to these uncertainties discussed above, the results are consistent with a number of other conclusions, including no change or even a growth in ozone levels.

We have an ozone trend detection system and it has shown ozone depletion has not been observed. The role of an ozone trend detection system, in the context of further research to determine net overall effects on ozone, is simply to detect any ozone increase or decrease in time to allow for the best possible international response based on the science. The FPP believes our ability to determine the best response will improve with further research, and that ozone trend analysis places limits on the risk - limits that decrease as more measurements become available.

GENERAL MOTORS COMMENTS ON ROVAC CORPORATION'S TESTIMONY AT JULY 23, 1981, SENATE HEARING ON CHLOROFLUOROCARBONS BEFORE SENATE SUBCOMMITTEE ON TOXIC SUBSTANCES AND ENVIRONMENTAL OVERSIGHT

To improve our automotive air conditioning system General Motors (GM) continues to investigate alternative systems as well as refrigerants vastly different from our current chlorofluorocarbon (CFC) R-12 refrigerant. These have included absorption cycle, thermoelectric, air cycle, steam jet, liquid nitrogen and hermetically sealed systems.

The ROVAC system with the air cycle compressor/expander has been evaluated by GM and found inferior to our current vapor compression systems in regard to cooling capacity, energy usage, size and weight.

The isopentane refrigerant proposed by ROVAC for use in their latest system is highly flammable and less energy efficient than our current CFC refrigerant (comparison to CFC refrigerant R-11 in ROVAC SAE Paper No. 810505 illustrates this result). Contrary to Rovac's new technology claims, the system described in their SAE paper is a vapor compression system basically the same as current commercial mobile air conditioners -- except that the mechanism is more complex and larger in size.

The current vapor compression CFC system provides good vehicle cooling with the best available combination of safety, nonflammability, low toxicity, low cost, low energy consumption and reliability. Therefore, we are concentrating our efforts on reducing CFC emissions through modification of the current vapor compression system and possible use of alternative refrigerant materials which are nonflammable, non-toxic and energy efficient.

GM has recommended that EPA adopt a policy of research and development for the CFC/ozone controversy to obtain better scientific information. We believe an entirely new air conditioning concept is unnecessary at this time and scientific efforts should be expanded to more completely understand the worldwide CFC/ozone issue. Regulation should be postponed until the issue and potential solutions are better understood.

President
Harold O. Buzzell

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1981 JUL 23 PM 4: 04

July 21, 1981

The Honorable Slade Gorton
United States Senate
Dirksen Senate Office Building, Room 3327
Washington, D.C. 20510

Dear Mr. Chairman:

The Health Industry Manufacturers Association (HIMA) wishes to submit the enclosed report -- Chlorofluorocarbons: 1981 Submission to the Environmental Protection Agency -- for the record of the hearings on chlorofluorocarbons (CFCs) to be held July 23 by your Subcommittee on Toxic Substances and Environmental Oversight.

HIMA is a trade association representing 253 U.S. corporations engaged in the manufacture of medical devices and diagnostic products. The majority of HIMA members are small businesses. Our industry employs CFCs in a variety of ways in the manufacture of products serving the U.S. health care system. CFCs are essential to our continued ability to manufacture safe and effective health care products.

We object to the Environmental Protection Agency's proposal to regulate CFCs since the hypothesis of ozone depletion by CFCs may not be true, and even if true, the extent of depletion and the assumed resulting hazards may not occur.

HIMA recommends that all proposals for CFC regulation be withdrawn until questions surrounding the ozone depletion theory and the extent of depletion are resolved. Should any regulations issue in spite this recommendation, HIMA requests an exemption for the medical uses of CFCs, which represent only 1 percent of all CFC uses.

Thank you for this opportunity to submit our comments and please contact us if you have any questions.

Sincerely,

Harold O. Buzzell

Harold O. Buzzell
President

Enclosure

cc: James Davenport, Assistant Counsel
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HIMA Report No. 81-2

CHLOROFLUOROCARBONS

1981 SUBMISSION TO THE ENVIRONMENTAL PROTECTION AGENCY

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March 1981

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March 11, 1981

Ms. Joni T. Repasch
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Washington, D. C. 20460

Dear Ms. Repasch:

The Health Industry Manufacturers Association (HIMA) is a trade association representing 253 U.S. corporations engaged in the manufacture of medical devices and diagnostic products. The majority of HIMA members are small businesses. Our industry employs chlorofluorocarbons (CFCs) in a variety of ways in the manufacture of products serving the U.S. health care system. CFCs are essential to our continued ability to manufacture safe and effective health care products.

On January 5, 1981, HIMA submitted preliminary comments in response to the Environmental Protection Agency's (EPA) Advance Notice of Proposed Rulemaking (ANPR) concerning Ozone Depleting Chlorofluorocarbons; Proposed Production Restriction (45 Federal Register 66726, October 7, 1980). We indicated in that submission that a more in-depth analysis would be provided at a later date.

We now submit the Association's comprehensive comments on the effect of non-aerosol controls of CFCs on the medical device and diagnostic products industry.

We appreciate your consideration of our comments.

Sincerely,

Hal Buzzell

Harold O. Buzzell
President

Attachment

cc: Mr. Gordon Olson

BEFORE THE
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

)
OZONE-DEPLETING CHLOROFLUOROCARBONS;)
PROPOSED PRODUCTION RESTRICTION:) 40 C.F.R. Part 762
ADVANCE NOTICE OF PROPOSED RULEMAKING.) OPTS-62009
45 *Fed*. *Reg*. 66726 (October 7, 1980))
)

COMMENTS

OF THE

HEALTH INDUSTRY MANUFACTURERS ASSOCIATION

March 11, 1981

PREFACE

The Health Industry Manufacturers Association, in these comments on proposed government regulations that would limit production of chlorofluorocarbons, strongly objects to the proposal and urges the Environmental Protection Agency to withdraw its Advance Notice of Proposed Rulemaking.

Our principal justification for this recommendation is that the scientific theory upon which the Agency bases the proposed regulation is speculative in that (1) the hypothesis of ozone depletion by chlorofluorocarbons may not be true, and (2) even if true, the extent of depletion and the assumed resulting hazards may not occur.

The above view is widely held, even within the Environmental Protection Agency. A September 10, 1980 memorandum from the Assistant Administrator for Pesticides and Toxic Substances to the Administrator recommending approval of the ANPR states:

> "The decision to initiate additional regulation of CFCs without experimental proof of the ozone-depletion theory presents an important question regarding the Agency's authority and willingness to take action despite uncertainty. The decision of the Agency to initiate further regulation to address the as yet unproven risk of ozone depletion despite the apparent lack of such a determination abroad (particularly in Western Europe) is a closely related issue."

A. INTRODUCTION

The Health Industry Manufacturers Association (HIMA) is a Washington-based trade association representing 253 corporations engaged in the manufacture of medical devices and diagnostic products. The majority of HIMA members are small businesses. HIMA ispleased to submit comments to the Environmental Protection Agency (EPA) outlining our evaluation of the Advance Notice of Proposed Rulemaking (ANPR) pertraining to chlorofluorocarbons (CFCs) published October 7, 1980. (45 Fed. Reg. 66726.)

Our comments on the ANPR are provided because EPA's proposed activity would impact many of our members who depend upon CFCs for the manufacture of medical devices and diagnostic products.

The comments submitted herein include an explanation of how CFCs are used by the medical devices and diagnostic products industry, comments and evaluations of major significance to our industry, and recommendations regarding the ANPR.

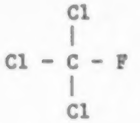
B. EXECUTIVE SUMMARY

On behalf of the medical device and diagnostic products industry:

- HIMA presents these comments on EPA's October 7, 1980 ANPR on CFCs.
- HIMA presents, in capsule form, the uses of CFCs by the medical device and diagnostic products industry; explains why substitute chemicals and/or alternatives to the use of CFCs are not available to the nation's health care system; and details briefly the essential nature of CFCs to our products.
- HIMA reports to the EPA thirteen specific evaluatins of the ANPR, each of which would be adequate cause not to continue with the regulation as presently proposed. Cumulatively, these evaluations clearly justify the recommendations made by the Association.
- HIMA concludes with the recommendations that EPA (1) withdraw the ANPR, (2) sponsor investigations of the CFC ozone depletion theory and the development of adequate non-depleting substitutes, and (3) perfomr continued ozone trend analyses as an early warning system for any alleged ozone depletion. Should a regulation issue in spite of these recommendations, HIMA requests an exemption for the medical uses of CFCs.

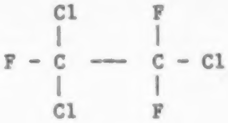
C. WHAT ARE CFCs?

CFCs are synthetic compounds which were developed in the 1930s. They consist of one - and two-carbon bases to which fluorine, chlorine, and sometimes hydrogen are attached. (Figure 1.) By substituting positions on the carbon base with a variety of halogens, different CFCs are produced which have unique physical and chemical properties.



$$\begin{array}{ccccc} & & \mathrm{Cl} & & \\ & & | & & \\ \mathrm{Cl} & - & \mathrm{C} & - & \mathrm{F} \\ & & | & & \\ & & \mathrm{Cl} & & \end{array}$$

CFC-11, a one-carbon compound



$$\begin{array}{ccccccc} & & \mathrm{Cl} & & \mathrm{F} & & \\ & & | & & | & & \\ \mathrm{F} & - & \mathrm{C} & — & \mathrm{C} & - & \mathrm{Cl} \\ & & | & & | & & \\ & & \mathrm{Cl} & & \mathrm{F} & & \end{array}$$

CFC-113, a two-carbon compound

FIGURE 1

As a family of chemicals, general CFC porperties include stability, nonflammability, low toxicity, compatibility with materials of construction, and heat transfer characteristics. These versatile characteristics account for CFC use in industries as diverse as refrigeration, plastic foam manufacturing, cleaning, and medical device sterilization.

The ozone depletion theory (next section) states that the chlorine portion of CFC compounds participates in the destructive activity. Therefore, if the chlorine content of CFCs is reduced, the alleged ozone depleting capability is likewise reduced. This also explains why different CFCs have different alleged ozone depleting capabilities.

The production of alternative CFC compounds involves the substitution of hydrogen, fluorine, or bromine in the position occupied by chlorine. In a compound such as CFC-11 (Figure 1), substituting a fluorine in a chlorine position (to make it $CClF_2$, which is CFC-12) should reduce the ozone depleting capability by one-third. However, by changing the chlorine content of the CFC compound, the unique physical and chemical properties also change. Therefore, alternative compounds may not possess the same characteristics of the original compounds and may be inappropriate for a given use.

D. THE OZONE DEPLETION THEORY

The family of chemicals called chlorofluorocarbons are widely used because of their inert, non-flammable and volatile properties. These same properties cause CFCs that pass into the atmosphere to have a relatively long life. The long life raises environmental questions as to the effect of CFCs on stratospheric ozone.

Ozone (O_3) is formed naturally and continuously from ozygen (O_2) by sunlight in the stratosphere, a layer of the atmosphere which exists approximately 8 to 30 miles above the ground. Ozone is a relatively unstable compound with a half-life of 3.5 minutes. There are also several natural processes that continuously destroy ozone in the stratosphere so that the amount present at any instant results from a dynamic balance of formation and destruction processes. The amount of stratospheric ozone varies naturally by as much as 50 percent at different locations and times.

Ozone absorbs part of the sun's radiation, thus limiting the amount of ultraviolet radiation penetrating to the earth's surface. If stratospheric ozone concentration is depelted (lowered), ultravioltet radiation reaching the earth's surface would be expected to be increased. Although ultraviolet radiation has both beneficial and detrimental effects, concern arises over an inadvertent increase of the bad effects. The effect that has attracted the most attention is the claimed correlation between ultraviolet exposure and the incidence of skin cancer in Caucasians.

One natural catalytic process that may remove ozone in the stratosphere is the chlorine cycle. There are other removal processes, but this is the process in which CFCs are believed to be involved.

Since CFCs are stable, at least a portion will slowly mix to the stratosphere. As they diffuse through and above the stratospheric ozone, they encounter more and more energetic radiation until they are broken down (photolyzed). This process frees the chlorine in the molecules, adds t the naturally available amount of chlorine in the stratosphere, and tends to make the chlorine cycle incrementally more effective.

The ozone depletion theory, therefore, is based on the reaction of nascent chlorine wiht ozone in the stratosphere. Chlorine atoms react with ozone to form chlorine oxide and oxygen.

$Cl + O_3 \rightarrow ClO + O_2$

The chlorine oxide in turn reacts with a nascent oxygen atom to yield chlorine and oxygen.

$ClO + O \rightarrow Cl + O_2$

The theorized reaction in the stratosphere is cyclic in that the chlorine resulting from reaction 2 is available to repeat reaction 1. The net result of one reaction cycle is that an atom of oxygen and a molecule of ozone is transformed to two oxygen molecules.

That these reactions and a resulting destruction of stratospheric ozone could be caused by CFCs was proposed by Molina and Rowland in 1974 [1].

The theory includes the following explanation of how chlorine from CFCs is available in the oxone layer of the stratosphere:

- CFCs have a long life in the troposphere and hense gradually diffuse to the stratosphere.

- Ultraviolet radiation in the stratosphere splits the CFC molecules to release atomic chlorine.

While there appears to be no widespread difference of scientific opinion as to the probability that the above sequence could occur, there is substantial controversy as to whether ozone depletion is actually occurring. Also, if depletion is assumed, there are serious differences of opinion as to the rate and extent of depletion and the consequences.

E. SUMMARY OF THE CFC ADVANCE NOTICE OF PROPOSED RULEMAKING

On October 7, 1980, the Environmental Protection Agency (EPA) issued an Advance Notice of Proposed Rulemaking (ANPR) (Appendix) entitled Ozone-Depleting Chlorofluorocarbons; Proposed Production Restriction. The ANPR described two major approaches for controlling chlorofluorocarbon (CFC) emissions. A Mandatory Controls Approach would limit CFC production through mandatory controls or technology-based standards and an Economic Incentives Approach would limit production through the distribution of marketable permits.

EPA implied its preference for economic incentives options and envisioned the approach to function through a restriction on CFC production, resulting in an increase in price as supply exceeds demand. As CFC prices are forced to rise, users would have an economic incentive to switch to substitute chemicals or alternative processes that reduce CFC consumption.

To implement the economic incentives approach, EPA would first rank CFCs (11, 12, 22, 113, 114, 115) by their theoretical ozone depletion potential. An overall ceiling for total production (a cap) would be established based on the sum of the individual productions in a base period factored by the individual theoretical depletion potentials.

The cap would be expressed in "permit pounds." Producers would have the flexibility of altering the product of the individual CFCs within the limits of the permit pound cap. The base period could be set at the production level for a specific recent year or by a formula combining several years' production figures.

To distribute the total amount of CFCs produced under a cap, EPA suggested three scenarios:

1. Direct allocation of production rights permits to producers which, says EPA, is of concern because of possible "windfall" profits to producers.

2. Direct allocation of production rights permits to users, which EPA feels would be more difficult to administer, although it would minimize transfer payments (payments made by users to producers or to goverment for the right to have x pounds of CFC produced).

3. Government auction of permits to producers, to users, or to both, which EPA feels would be the simplest to administer and would be the most equitable because permits could be further traded or sold.

In dealing with exports and imports, in bulk or in articles, EPA suggests several options. Exports could fall under the domestic production ceiling, be excluded from the domestic ceiling, or have certain use categories excluded. Additionally, imports could be frozen at current levels, have a separate permit system, or be included in the domestic ceiling, in which case importers would bid for permits against domestic producers.

EPA invited comments on all aspects of the ANPR. It especially solicited comments on:

1. the scientific validity of the ozone depletion theory;

2. risks to health and environment of continued world CFC emissions;

3. strategies for level of CFC control, i.e., the validity of a production ceiling strategy versus wait and see or substantial emissions reduction;

4. how to improve the level of international cooperation and issues related to the import and export of CFCs; and

5. approaches to achieving a production ceiling, i.e., comments on the economic incentives approach versus mandatory controls, desirability of the auction and allocation methods, permit pound concept, and methods of directly allocating or auctioning permits to producers or users.

F. HOW THE MEDICAL DEVICE AND DIAGNOSTIC PRODUCTS INDUSTRY USES CFCs

Listed below are the main uses of CFCs in our industry:

1. Diluent for ethylene oxide in the sterilization of medical supplies.
2. Degreasing and cleaning agent.
3. Deflashing and burr removal agent.
4. Manufacture of gaseous anesthetics.
5. Application of silicone coatings.
6. Freezing systems for the preservation of blood.
7. Extraction of lipids from serum products.
8. Presurgical skin-degreasing.
9. Cryogenic surgery (e.g., cataract removal).
10. Leak testing.
11. Medical refrigeration systems (e.g., organ maintenance and transport).
12. Foam plastic products for health care.
13. Miscellaneous components for medical devices.
14. Propellants for medical products

While some of the above uses are the same as non-medical uses, others are unique to our industry. We discuss some of these uses and make comments on alternatives below:

1. As a Diluent for Ethylene Oxide - Dichlorodifluoromethane and trichloromonofluoromethane are the two CFCs most frequently used as diluents for ethylene oxide, with the former being most prevalent. Mixtures of these CFCs and ethylene oxide are used by hospitals and industrial companies for sterilizing materials, apparatus, and equipment for the health care field that cannot be sterilized by other means using current bacteriological practices and knowledge. Approximately 14 million pounds per year of CFCs are used in medical product sterilization.

   There are two alternate means of delivering ethylene oxide to goods for sterilization -- pure ethylene oxide or an ethylene oxide-carbon dioxide mixture.

   a. Pure Ethylene Oxide - is highly volatile, flammable, and explosive in all mixtures with air containing from 3 percent to 100 percent ethylene oxide. Considerations of safety in transit, storage, and use present great potential hazards which rule out use of pure ethylene oxide in hospitals, clinics, and laboratories. Because of product ethylene oxide residue restrictions by the Food and Drug Administration (FDA) and ethylene oxide worker safety requirements by OSHA, limitations on CFC use would increase the industry's problems in meeting present regulation requirements.

b. Ethylene Oxide-Carbon Dioxide Mixture - Although one method to render ethylene oxide nonexplosive is to use it as a 10 percent mixture with CO_2 (Carboxide), this is not a satisfactory solution. This mixture has a vapor pressure of 800 pounds per square inch and, therefore, must be shipped in heavy steel cylinders.

Sterilizing gas issued from these cylinders tends to be nonuniform in composition since there is a high potential of stratification and separation by the CO_2 mixture in the chamber. Because of fractionation of the mixture, the ethylene oxide content of the sterilizer varies. Specific EtO content is not guaranteed and, thus, proper sterility assurance is not guaranteed. To obtain reproducible levels of EtO in a sterilizer, the EtO-CO_2 mixture must first be delivered to an expansion tank. In addition, carboxide can only be admitted to sterilization chambers at 130°F which creates an ethylene oxide concentration of about 360 milligrams per liter in a chamber that can withstand 15 psig. CFC-containing mixtures produce concentrations of EtO about 880 milligrams per liter. The EtO-CO_2 mixture, therefore, requires about two and one-half times the exposure time to sterilize the same goods as an EtO-CFC mixture. This is undesirable for hospital and industrial uses since it necessitates a greater investment in sterilizing equipment and is not a reliable process. The longer exposure time necessary with the CO_2 diluent produces greater residues of ethylene oxide and its breakdown products, ethylene glycol and ethylene chlorohydrin. The amounts of these residues are subject to a pending FDA regulation.

In addition, the EtO-CO_2 mixture has a flammable nature as compared to the non-flammable characteristics of the EtO-CFC mixture. Because the CFC mixture is non-flammable, the code which requires damage limiting construction (outside wall to serve as blow-out point) for sterilizers is not in effect and sterilizer location does not become a factor. Since many hospital sterilizers and industry sterilizers are located deep within the facility, a major relocation cost impact would ensue if the EtO-CFC mixture were restricted.

The use of EtO-CO_2 for currently available EtO sterilizers is not a suitable substitute because of the high chamber pressure required. This pressure requirement would be much higher than that required for EtO-CFC. Generally, the

EtO-CO_2 pressure required for sterilization is 27 psig while that of EtO-CFC is 9/10 psig. These vessels which were designed for EtO-CFC mixtures have a pressure rating of 36 psig as approved by the American Society of Mechanical Engineers (ASME). Therefore, the incorporation of EtO-CO_2 would not allow for satisfactory pressurization of the chamber and could cause all hospitals and many industrial users to purchase new equipment to meet the safety standards.

Should the sterilizing facility own a pressure vessel capable of withstanding the increased pressure, the sensing gauges and control instrumentation still would have to be replaced to convert from CFC mixtures to CO_2. Even then, the maximum attainable ethylene oxide concentration would only be about half that of the CFC mixture, and extra sterilizing capacity would be needed.

Another consideration when using higher pressures for sterilization is the packaging of the medical device. Most devices are packaged in a heat sealed "pouch." Increased pressures could cause the pouch to rupture or burst. Therefore, the use of a carboxide mixture would require the re-evaluation and subsequent re-design of all medical devices sterilized in this manner. The costs of repackaging, in addition to the capital investment for modifying sterilizers, would significantly increase the cost of all sterilized medical products.

Due to the risks and expense involved in carboxide mixtures, only about 50,000 pounds of ethylene oxide are used per year in CO_2 mixtures for sterilization, compared with about 7,500,000 pounds of pure or CFC-mixed ethylene oxide used annually for sterilization.

A considerable percentage of ethylene oxide device sterilization involves products under the supervision of the FDA. With respect to such products, procedures and specifications for manufacturing, including preliminary and terminal sterilization of raw materials, containers, packaging, and final products, are established and provided to the FDA. These procedures and specifications must meet FDA requirements. Any variation in procedure must be validated and shown to be safe for use on the materials being sterilized. For example, carbon dioxide is not an inert material; substituting it as a diluent for CFC mixtures could be expensive and could seriously interrupt medical device production. Further, CO_2 reactions with many materials could create toxic chemicals, thus prohibiting its use.

c. Hospital Sterilization - Although alternate methods of sterilization exist, including steam sterilization, formaldehyde gas treatment, and chemical solution treatment, none of these methods are currently available in hospital settings as feasible replacements for the EtO-CFC mixture.

The types of materials and devices sterilized are almost without exception items whose physical condition and/or composition is such that they would not withstand treatment by other available sterilization methods (primarily steam under pressure and dry heat). Such devices or materials would melt, warp, become brittle or dull, or otherwise be rendered unusable by heat treatment. In many instances, the useful life of very expensive instruments would be seriously reduced. Redesign of the vast array of items sterilized in hospitals by EtO-CFC would require many years, and would add tremendous costs to the health care system. Therefore, steam under pressure and dry heat sterilization are not practical substitutes for most materials presently treated with EtO-CFC.

Formaldehyde gas exhibits sterilization properties and is used to a limited extent in other countries. Formaldehyde sterilization processes, however, are less efficient than EtO processes primarily because of reduced volatility and permeability. These deficiencies also create removal and accrual problems for formaldehyde. Irrespective of this, formaldehyde is not a viable EtO-CFC substitute for the following additional reasons:

- The lack of adequate instrumentation and processing.
- Its potential toxicity. Formaldehyde is an alkylating agent and exhibits toxic properties. It would require years for hospitals to learn how to deal with this agent in its gaseous form and to achieve the same level of safety as exists today with EtO-CFC. The final result might well be a hazard level of unacceptable magnitude with less efficiency in achieving sterility.

Chemical solution soaking is also unacceptable to hospitals for the following reasons:

- Chemical solution soaks lack the efficiency and the assurance of sterility provided by EtO-CFC. Many materials cannot be soaked without damage. Items "sterilized" by chemical soaks would probably be recontaminated by the packaging process.

- Widescale use of chemical soaks would probably create numerous toxic and other hazards since many chemical disinfectants are also alkylating agents and all have toxic properties. The problem with residuals on soaked products would be severe and widescale use would most certainly result in accumulation of persistent toxic chemicals.

For hospital sterilization, there is no substitute for the EtO-CFC mixture, and most medical and hospital devices would be of a non-sterile nature if Phase II controls ensue. In addition, there is no question that the nosocomial (hospital acquired) infection rate would rise to levels experienced before the advent of the EtO-CFC sterilant mixture.

In summary, there are no other suitable substitute gases for CFCs in EtO sterilization.

2. For Extraction of Lipids from Sera - Trichlorotrifluoromethane is used to extract lipids (fats) from human serum products. There are no non-fluorocarbon compounds that may be used in place of this CFC at this time. Since human serum products are licensed by the Bureau of Biologics (BOB), if another solvent were available, it would have to be tested extensively before use to show that it would not affect safety and efficacy. Thus, limitations on CFCs would present a double problem for the diagnostic product industry because there is no solvent that is:

   a. recognized as an effective substitute for trichlorotrifluoromethane and

   b. approved for use in licensed human serum products.

3. As a Cleaning, Degreasing, and Drying Agent - Trichlorotrifluoromethane is used as a cleaning agent for polycarbonate, polypropylene, and other plastic components in a large number of medical devices. Failure to remove the contamination can result in a toxic reaction by the patient to the contaminant, an electrical malfunction of the device or a structural failure of the device. Industry's choice of CFCs for these activities is based on several factors:

   a. low (noxious) fume level,
   b. non-corrosion of parts,
   c. low flammability risk, time stability,
   d. low residue on parts, and
   e. non-toxicity.

The cleaning operation typically occurs within a degreasing system designed to recover and purify the solvent via distillation. Occasionally, however, 10-50cc volumes are used to clean surfaces in a manual wiping procedure, relying upon evaporation for solvent removal. This category of CFC use was evaluated by NAS and two "promising alternatives" were identified, non-aqueous and aqueous cleaners. However, for degreasing, cleaning, and drying operations in the medical device industry, neither of these alternatives would be acceptable because of their potential toxic effects on medical implants and other critical devices.

A possible alternative solvent for some selected activities would be isopropyl alcohol. However, odor and residue levels would be higher and more bothersome. More importantly, the impact on the safety and function of such important devices as heart valves, artificial lungs, and artificial kidneys is unknown, and use of this substitute would require extensive testing.

Therefore, CFCs, alone or in blends, act as solvents for an extremely broad range of contaminants common to medical device manufacture. The substitute solvents so far developed are generally less universal and tend to leave residues. Generally, this means that a greater number of solvents will be required to adequately clean a device during manufacture, and that some additional solvent will be required to remove the residues of the initial cleaning solvents. The inevitable result is an increase in the total volume and variety of solvents used. Because all substitutes developed to date have one or more hazardous properties, decreased use of CFC's would lead to increased production of hazardous wastes which must be recycled or permanently disposed of.

If industry is required to find and qualify other agents, extensive research, development, and clinical retrials will be required. Depending upon the degree of FDA regulatory controls (approval of solvent substitutes, new materials, and new manufacturing facilities) for some devices, the costs of eliminating CFCs could range from $200,000 to $800,000 per device firm.

Condensation methods may be used to control and recover some CFCs. If CFCs for medical uses are not available, expensive closed-loop condensation or charcoal filtration methods would be added to present processes or to recover the remaining evaporative losses. These might cost up to $100,000 per company to develop.

These costs, in addition to at least one year to control (or two years to replace) existing CFCs, are reasonable estimates of the direct impact on many device companies. Such controls could also have serious indirect effects in decreasing the time and money available for research and development of medical products.

4. As a Solvent - The NAS report gives the 1978 CFC utilization as solvents at 81 million pounds. A very small portion of this is used by the medical device industry for the cleaning of electrical, electronic, and mechanical assemblies. The NAS study failed to identify any promising alternatives for this CFC application nor any potential alternatives requiring further research.

   Two alternatives were considered and rejected. The possibility of containment, recovery, and recycling of CFCs used for part cleaning was rejected because of very high cost -- even if this technology were feasible. The use of other solvents was rejected because of effects on product quality and the creation of health and safety hazards.

5. Leak Testing Application - Many aspects of medical device assembly, containment, and processing equipment used in manufacturing require a practical and reliable method of testing for minute leaks. Uncontrolled leaks can affect patient safety. Closures used for medical device research and production must often provide absolute containment to ensure adequate safety for industry personnel and for the final product.

   CFCs, in conjunction with halogen leak detectors, are widely used for this purpose. Typically, small amounts of CFC gas are put in the apparatus to be tested and air is used to raise the internal pressure slightly above atmospheric. Halogen-sensing devices are then used to "sniff" gasket and weld areas for leaks. This is ideal because CFCs are non-toxic, non-flammable, and leave no contaminating residues. Known substitute methods would be vastly more expensive or inadequate in sensitivity and could create explosive or other hazards.

6. Presurgical Skin Cleaning - A very small amount (approximately 100,000 lbs/yr) of CFCs are used in hospitals as presurgical cleaners. CFCs are ideal for this use because they remove bacteria-laden oils from the skin and improve subsequent adhesion of surgical drapes. Moreover, CFCs replaced the use of diethyl ether which was not desirable because it is highly flammable and toxic. Thus, this use of CFCs in surgical procedures has not only reduced the risk of fire and explosion in hospital operating rooms, but has lowered the risk of toxic patient reactions as well.

   The NAS report lists both diethyl ether and alcohol as potential alternates for CFCs for presurgical skin cleaning. However, neither are acceptable -- alcohol is not an effective agent for this purpose, and diethyl ether is presently prohibited because of fire hazards.

7. Manufacture of Gaseous Anesthetics - CFCs are used as a starting feedstock for the manufacture of many gaseous anesthetics. These are obviously essential to the health of the care system. The use of CFCs results in almost total conversion of the feedstock and little of it escapes to the environment. Continued use of CFCs for this important purpose is warranted. Under the present proposal, it would be unfair for manufacturers of anesthetics to suffer shortages and higher CFC prices.

8. Liquid Fast Freezing - This use of CFCs is primarily for the production of frozen foods, with only a fraction used to freeze medical and biological specimens. While liquid nitrogen or liquid CO_2 systems would be substituted for CFCs, they would utilize 9 to 10 (N_2) or 17 to 20 (CO_2) times more energy. Other methods such as air-blast techniques would result in poorer product quality which, in the case of medical uses, would be unacceptable.

9. Application of Silicone Coating - CFCs are used as a media dip for certain medical device components to be coated with silicone compounds. This process is esential for the proper binding of the silicone, and the non-toxic nature of CFCs makes them ideal to insure patient safety. There are no FDA certified and acceptable substitutes for their use.

Summary

CFCs are used by industries serving the health care field in at least fourteen distinct ways. These uses are essential to the supply of products required for efficient delivery of health care. For these health care uses, the unique and non-toxic properties of CFCs are such that practical substitutes are not available. CFCs used for health care product production comprise a small portion of the total U.S. utilization. Some recapture and reuse of CFCs occurs, and this will be increased as technology develops. Even if substitutes were available for some uses, problems of product toxicity testing and FDA approvals would impose a severe hardship on the industry and result in substantial product cost increases passed on to the American public.

G. EPA's PHASE I RESTRICTIONS ON CFCs HAVE ALREADY ADVERSELY AFFECTED HEALTH CARE

The EPA, in conjunction with the Food and Drug Administration (FDA), and the Consumer Product Safety Commission (CPSC), outlawed most aerosol uses of CFCs in August 1978, when Phase I controls became effective. HIMA, in oral testimony and written submissions, strenuously opposed these controls and specifically requested that, if Phase I controls were issued, appropriate exemptions be provided to the health care industry.

Presently, exemption from Phase I controls for products of an essential nature or with no suitable alternatives may be obtained from EPA. However, for the health care industry, all exemptions for products containing CFCs must be obtained from FDA. FDA's major criteria for granting an exemption for a medical product are:

1. There is no technically feasible alternative to the use of a CFC in the product.

2. The product provides a substantial health benefit, environmental benefit, or other public benefit that would not be obtainable without the use of CFCs.

3. The use does not involve a significant release of CFCs into the atmosphere, or that the release is warranted in view of the consequences if the use were not permitted.

CFCs are important as propellants for a number of medical devices and products.

It has been the experience of a number of medical device firms that obtaining an exemption for CFC use from FDA is extremely difficult. One exemption request of which we are aware consisted of an automatic suturing device which was propelled by a miniscule amount of CFC gas. This device satisfied criteria 2 and 3 (stated above). However, it was the view of FDA that a technically feasible alternative (criteria 1) did exist to an automatic suturing device -- sutures sewn in the traditional manner by the physician. Thus, the exemption was denied.

We are alarmed at the hindsight exhibited by FDA in denying a number of applications for technically advanced and possibly life-saving medical products due to a miniscule CFC content. We question whether the EPA is aware of the particular enforcement strategy used by the FDA, and how it relates to the EPA's enforcement strategy.

It is apparent that our industry has already been adversely affected by Phase I controls of CFCs. The potential adverse effects created by the proposed Phase II controls will be enormous. Every sector of the health care industry will experience shortages or the potential loss of essential products.

As an Assocation devoted to improving health care, we are also concerned with the health affects associated with Phase I controls. Originally, CFCs were developed to provide safety and avoid the hazards of explosion, flammability, and toxicity of the propellants and refrigerants they replaced. However, with Phase I controls, the flammable and explosive propellants propane and butane were substituted. These hydrocarbons are photosynthetically reactive and break down at ground level, contributing to the accumulation of "ground level ozone," a significant component of air pollution. CFCs, however, are not photosynthetically reactive, do not break down at ground level, and do not contribute to ground level ozone.

In addition, the fires and explosions at aerosol loading plants, due to the substitution of butane and propane, have already killed and injured more people than were ever projected in the calculations for Phase I and II controls.

In summary, Phase I controls have affected the health care industry by keeping new and technically advanced essential products out of the market. In addition, Phase I controls have also introduced health hazards through the use of air-polluting, explosive and flammable propellants.

H. HIMA'S PRINCIPAL COMMENTS ON THE ANPR

1. The Proposed Regulation is Based on an Unproven Scientific Theory

EPA's proposal is presented as if there were no doubt as to its scientific accuracy. There is, however, substantial question surrounding the accuracy of theoretical ozone depletion estimates. Measurements over the past 20 years show no evidence of depletion, while the theory relied on by EPA suggests a 2.3% depletion should have occurred. Some analyses of measurements have even suggested an increase in the ozone layer.

Following Molina and Rowland's publication in 1974 [1], a number of studies on the potential effects of anthropogenic chlorine on the ozone layer were begun. A National Academy of Science (NAS) report in 1976 [2] and a report by the National Aeronautics and Space Administration in 1977 [3] suggested that a problem probably existed. They also referred as well to uncertainties and gaps in the models and in our understanding of stratospheric chemistry.

EPA, in the publication of the ANPR, used these studies and relied heavily on two 1979 NAS publications [4,5]. The November 1979 NAS report [4] estimated an 18.5% ultimate depletion of stratospheric ozone. This figure, based on a computer model, was adjusted downward to 16.5% in an attempt to compensate for the impact of a number of uncertain factors. In December 1979, NAS published information on the global effects that might result from the loss of 16% of stratospheric ozone [5].

HIMA, in evaluating various predictions of ozone depletion, believes the ANPR does not give adequate consideration to:

- The fact that real measurements of stratospheric ozone do not show a decrease, but actually reveal an increase (see page 26).
- The October 1979 report by the United Kingdom's Department of the Environment [6].
- Brasseur's 1980 review for the European Economic Communities (EEC) [7] and a subsequent report to the Council of the EEC [8].
- Research in atmospheric chemistry recently published.

Some of the above information was not available to the EPA during the preparation of the ANPR. Nonetheless, any contemplated regulation must be based on the latest and best scientific evidence.

It is HIMA's position that the predictions of ozone depletion from computer models are not sufficiently accurate and lack scientific consensus to the extent that they do not justify present regulation of CFCs.

DuPont Company has reported to EPA [9,10] that their critique of the NAS reports shows that major uncertainties in the model were underestimated and conclusions about ozone depletion effects are not supported by present knowledge.

The United Kingdom report [6] concluded:

> "Present understanding of ozone depletion is limited and based on model assumptions which have not been adequately validated"; "strict regulation is not warranted."

The report to the Council of the EEC [7] states that computer models used to predict ozone depletion are simplified and unable to adequately describe the behavior of the atmosphere and minor constituents such as ozone. The report concluded that "... at present there is nothing to indicate that CFCs have had a genuine effect on the ozone layer."

The report to the EPA by the Alliance For Responsible CFC Policy* [11] provides additional current information detailing many of the model's uncertainties and suggests that the impact of new knowledge about atmospheric chemistry either invalidates the NAS predictions or greatly lowers the depletion percentage figures. Some examples are summarized in the following paragraphs.

Calculations of ozone depletion are based on model programs done by a computer that attempt to simulate the atmosphere and predict occurrences. In order to do such modeling, certain assumptions must be made. These assumptions often are "best guesses" whose reliablity is unknown but whose effect on the prediction may be great. One assumption made, for example, is that all the CFC released to the atmosphere reaches the stratosphere. The effects of temperature and pressure on reaction rates and the effects of other chemical moities in the atmosphere are examples of factors that create significant uncertainties in the results of model predictions.

Hydroxyl (OH) radical reactions may moderate the chlorine available to react with ozone in the stratosphere and thus greatly change depletion predictions. There are recent indications that the OH concentration of the lower stratosphere is significantly lower than previously estimated. Hydroxyl radicals determine, in part, the amount of chlorine available through reactions with hydrogen chloride to yield chlorine and water:

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*HIMA is an associate member of the Alliance for Responsible CFC Policy.

$$OH + HCL \rightarrow Cl + H_2O$$

Thus a lower average OH concentration in the stratosphere would significantly reduce calculated ozone depletion rates.

Whether certain other chemical reactions do or do not occur in the atmosphere is of significance to the accuracy of the computer model projections. The Alliance For Responsible CFC Policy [11] has identified three typical reactions where the possibility of alternate reaction products is possible and where the alternate products would make significant differences in calculated ozone depletion rates:

1. The reaction of hydroxyl radicals with chlorine oxide:
   $HO + ClO \rightarrow$

   The assumed resultant products are:

   (a) $HO_2 + Cl$, or
   (b) $O_2 + HCl$

2. The reaction of hydrogen dioxide with chlorine oxide:
   $HO_2 + ClO \rightarrow$

   With two possible sets of products

   (a) $O_2 + HOCl$
   (b) $O_3 + HCl$

3. The effect of ultraviolet radiation on the radical HOCl:
   $HOCl + UV \rightarrow$

   With two possible sets of products:

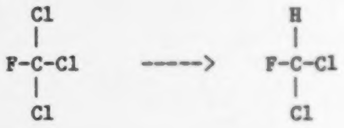
   (a) $HO + Cl$
   (b) $O + HCl$

It should be noted in the three above reactions that the second reaction pathway results in the formation of HCl and thus acts to remove chlorine from the postulated ozone depletion cycle. Howard [12] has pointed out that, even if 10 percent of the reaction products went the (b) pathway, this would substantially reduce the calculated ozone depletion amounts.

As with other recent evidence relating to the ozone depletion theory, the above data suggest that a large uncertainty exists as to the accuracy of the computer models and that models tend to overestimate ozone depletion rates.

Should degradation of some CFCs in the troposphere occur, the calculated rates of ozone depletion would be lowered. An experiment being conducted by Cunnold et al. [13] demonstrates that possibility. This experiment, the Atmospheric Life Experiment, is concerned with establishing the lifetime of CFC-11 and -12 in the atmosphere. Completion is scheduled for 1982, but 18-month data indicate the possibility of a shorter lifetime than expected -- a result that would reduce calculated ozone depletion rates.

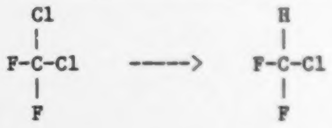
Directly related to the CFC lifetime issue is the work of a number of investigations on the relationship of CFC-11 and -12 and CFC-21 and -22 [14,15]. For example, measurement in the atmosphere of more CFC-21 than can be accounted for from anthropogenic sources suggests the following possible degradation mechanism:



$$\underset{Cl}{\overset{Cl}{F-C-Cl}} \dashrightarrow \underset{Cl}{\overset{H}{F-C-Cl}}$$

(CFC-11) (CFC-21)

CFC-21 obviously has one-third less nascent chlorine available. The similar degradation of CFC-12 to CFC-22 would be:



$$\underset{F}{\overset{Cl}{F-C-Cl}} \dashrightarrow \underset{F}{\overset{H}{F-C-Cl}}$$

(CFC-12) (CFC-22)

Here CFC-22 would have only one-half the potential of CFC-12 for reducing stratospheric ozone.

One possible mechanism for CFC degradation involves sand surfaces. Decomposition on silica surfaces has been studied by Ausloos and

Rebbent [16] and Ausloos et al. [17]. Additionally, high concentrations of CFC-21 were detected by Crescentini and Bruner [14] in air over the Sahara Desert. Finally Rasmussen et al. [15] found larger than expected amounts of CFC-22 in the troposphere.

An uncertainty in computer models deals with the transport of CFCs. Transport includes both the vertical and latitudinal movement of atmospheric components. Because different transport parameters are used by various scientists and because they vary significantly, real uncertainties as to the effect of transport on the calculated ozone depletion values exist.

Still other uncertainties with model calculations of depletion involve the need to evaluate the effects of increasing amounts of CO_2 and N_2 in the environment. Studies with CO_2 by Groves and Tuck [18] and with N_2O by NAS [4] suggest that the effects of these constituents may reduce calculated ozone depletion amounts.

Finally, a test of the accuracy of the computer models results from a comparison of predicted levels of chemicals with levels obtained by actual analytical measurement methods. Differences observed with several chemical species identify discrepancies not readily explained or results inconsistent with the ozone depletion theory. A discussion of these with chemical species such as ClO, HCl, NO and HNO_3 has been provided to EPA by the Alliance For Responsible CFC Policy [11]. The United Kingdom report [6], referred to earlier, commented on the significance of the discrepancies between model calculations and actual measurements as follows:

> "It follows that if we are not satisfied with our present ability to simulate (with computer models) the natural stratosphere, particularly on the grounds that there may be major errors or omissions in current theory, we must be very cautious in accepting quantitatively any predictions from accompanying perturbation experiments." (UK DOE, 1979, p. 143.)

With respect to ozone depletion predictions made by computer modeling and used by EPA as justification for the ANPR, it is HIMA's position that the proved inaccuracy of the predictions, the inconsistencies with actual measurements, and the weight of scientific opinion requires the EPA to withdraw the present ANPR and base any future regulation on a more secure and factual scientific base.

2. Ozone Depletion Has Not Occurred

Measurements of ozone have been made at a number of locations for varying periods of up to 20 or more years. An analysis method called the time series analysis* has been used with the measurements but early efforts apparently were unable to increase and validate the sensitivity of the method. The 1979 NAS report [5] recognized this and concluded that the time trend analyses, while promising, were not suitable for detecting small ozone trends. Summarized below are some recent studies which HIMA believes show that time trend analysis (also called ozone trend analysis) is valid and sufficiently sensitive to dependably detect small changes in stratospheric ozone.

In 1975, Hill and Sheldon [19] used Dobson measurements taken between 1932 and 1970 from Switzerland and applied time series analyses. Hill et al. [20] and Pagano and Parzen [21] used a larger base of ozone data to do analyses. The work of Hill et al. [20], as well as Tiedle et al. [22], led to the conclusion that evidence of any ozone depletion was lacking and that, in fact, a trend toward an increase of 1.5 percent was suggested by the analyses. These authors, however, stated that the trend could be due to instrument drifts.

What has happened since the publication of the NAS report is critical to the issue of ozone measurement. The published research of Reinsel et al. [23], and St. John [24,25] allows significantly different interpretations of time series analysis data than that suggested by NAS. In effect, we now have much more confidence that depletion has not occurred because we have additional data confirming the validity and sensitivity of the analysis method.

For example, the research by Reinsel et al. considered statistical, instrumental, and geographical errors in analyzing Dobson ozone measurements from 36 stations worldwide. This enabled them to make estimates of trends on a global basis. For the years 1970-1978, these researchers concluded that a global increase of stratospheric ozone of 0.28 ± 1.4 percent has occurred. The uncertainty limits of their analysis was ± 1.4 percent (much lower than that given by NAS in 1979). On the basis of the above, Reinsel et al. concluded that globally no ozone depletion had occurred.

In two publications, St. John used a different approach. The records of 14 Dobson stations, covering data from the years 1958 through 1978, were studied. This analysis showed an ozone increase of 0.3 ± 1.2

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*A time series is a set of measurements in time such that each may be related to previous measurements. Time series analysis is a statistical technique to analyze the time series for patterns, cycles, or trends and to evaluate them quantitatively.

percent. Then St. John extended his analyses to cover 1979. Here the result was similar, an average trend of a 1.5 ± 1.0 percent increase was found.

HIMA believes it significant that no suggestions of ozone depletion from actual measurements are advanced by the above research reports.

Umkehr measurements also deserve mention. These relate to measurements of several distinct stratospheric layers of ozone rather than column measurements which represent the total ozone from the surface of the earth to the limits of the earth's atmosphere.

Using Umkehr measurements, studies by Angell and Korshover [26] testified to the absence of ozone depletion:

> "The 1979 data suggest the highest global total-ozone value since 1970, or a value a significant two percent above average."

These authors concluded, "Thus, this is still no evidence of an anthropogenically-induced decrease in ozone in this sensitive layer."

Angell's previous report in 1978 [28] provided analyses of a specific altitudinal region, the region 32-40 km above the earth's surface. Concentrating specifically on this region, Angell concluded that during 1964 to 1972, a 12 percent increase in ozone concentration occurred.

In evaluating existing data on ozone levels it is important that the measurements reasonably represent the true global average ozone concentrations and are accurate and sensitive enough to measure small changes and trends. Research published since the 1979 NAS report strongly suggests that both points are true.

Tiao's [28] recent report shows that the Dobson network does yield ozone measurement data that represent a global average. The study involved analysis of 1970-1977 Nimbus 4 satellite ozone data in geographical regions near 36 Dobson stations where measurements were also made. The trend in average ozone levels from the two sources was identical.

As far as sensitivity is concerned, the Dobson total column ozone measurements are more reliable than the Umkehr stratospheric layer measurements because the former have been subjected to time series analysis. Of course, it is important to note that measurements by both methods show increased ozone concentrations. The research by St. John et al. [24,25] using Dobson measurements provides a good analysis of method sensitivity. The analysis provided uncertainty limits (95 percent confidence) for detecting ozone measurement trends in the range of ± 1.0 percent to ± 1.5 percent. During 1958-1979, the best trend estimate of ozone above 14 Dobson stations was an increase of 1.5 percent. Applying the 95 percent confidence limits of ± 1.0 percent means in this instance that there is only a one in 40 chance that the increasing trend is less than + 0.5 percent (e.g., ± 1.5 -1.0) and a one in 40 chance that it is greater than 2.5 percent (e.g., +1.5 +1.0). Thus, the sensitivity of the methods is now known to be sufficient and can be used as an early warning system if downward trends in ozone levels occur in the future.

HIMA's conclusions concerning the actual measurements of ozone, as compared to the hypothetical ozone values derived from the computer model, are as follows:

- No ozone depletion has occurred.
- Ozone levels appear to have increased by more than 1.0 percent. The measurement methods used are sensitive enough to detect any future downward trend in ozone levels.
- While it is premature to suggest that the depletion theory is not true, it is reasonable to conclude that factors not well understood could be compensating for any ozone losses due to CFCs.
- The EPA should withdraw the ANPR. The Agency should perform (with CFC producers and academia) the sufficiently sensitive ozone trend analyses. These can be used as an early warning system for ozone depletion.

3. Any Further Regulation of CFCs Should Await Scientific Confirmation of the Depletion Theory

EPA relies only on the 1979 reports of the National Academy of Sciences [4,5] to justify regulation of CFCs. In fact, there are two studies that contradict the NAS reports -- a study by the Department of Environment in the United Kingdom [6] and a study done for the European Economic Community [7] recommend further research before considering regulation. In view of this contradictory scientific evidence, it is premature to take any action now. It effectively would result in a measurable and immediate regression of today's health care standards because of a disputed allegation of potential future health risks.

We therefore urge the EPA to consider the following action items:

- Participate in or support an effort to further assess and develop ozone trend analyses to provide a measurement technique acceptable to government, academia and industry.

- Arrange for or participate in further objective studies on the ozone depletion theory and its effects. This should be an international effort.

- Develop, for future use, criteria relating to all the decision points to be used in CFC regulation.

- Drop the idea of regulating CFCs in isolation and concentrate on what effects and controls are needed considering all ozone increasing and all ozone depleting compounds and effects.

4. In Spite of the Controversial Scientific Evidence, EPA Has Prejudged CFC Issues.

Regulatory procedures implemented under due process must be done in an atmosphere of impartiality. When an agency seeks data and comments from the public, as in the case of this ANPR, it must do so without prejudging issues. To do otherwise makes a mockery of due process procedures.

Premature actions by the EPA regarding the ANPR have resulted in unfortunate prejudging of certain essential issues. These issues, as discussed elsewhere in this document, involve the validity of the ozone-depletion theory and the probability that any such depletion would endanger public health and welfare in a manner sufficient to warrant regulatory actions. These are scientific determinations that should be left to the scientists. It is only after sufficient scientific consensus exists that it is fully proper for those responsible for regulatory action to announce conclusions and plans based on those conclusions. The EPA has acted contrary to this and has thus prejudged issues in a number of instances.

On April 15, 1980, months before several significant reports on ozone depletion were issued, EPA Deputy Administrator Barbara Blum announced at an international meeting in Oslo, Norway what was concluded about the effects of CFC emissions and what regulations the United States was going to issue.

For example, Deputy Administrator Blum stated:

> "Imposing a production ceiling in the United States is neither the first, nor the last, step to control chlorofluorocarbons ...
>
> "The action I am announcing today conveys the urgent and deep concern of the U.S. about the threat chlorofluorocarbons continue to pose. Our country is moving forward now because we believe that chlorofluorocarbons comprise one of the leading international environmental issues of the decade."

Further, the above-stated Oslo Conference on CFCs is suspicious because it would appear that only countries known to be somewhat in agreement with EPA's determination to impose production restrictions may have been invited. As an example, Norwegian officials suggested that Belgium not be encouraged to attend because it did not meet the proper criteria.

The October 1980 EPA Journal described ozone depletion by CFCs as a scientific fact, rather than correctly stating it to be an unverified theory. An April 2, 1980 EPA letter sent to a number of industry representatives makes the same prejudgements, even to the point of concluding how much of a CFC reduction (over 1977 levels) would be necessary.

Other letters by Douglas Costle, Barbara Blum, and Steven Jellinek prior to the ANPR clearly show that the agency had already decided the outcome of the ozone depletion theory, its consequences and the regulatory actions it wished to take.

- "new scientific evidence makes it clearer than ever that additional regulation is necessary worldwide in the near future. The wait and see policy is unacceptable." [11, p. IV-6]]
- "further actions will be necessary to slow or eliminate growth in CFC use and eventually to reduce worldwide usage levels." [11, p. IV-5]
- "in the long term, further reductions will be necessary, possibly on the order of 50 to 70 percent reductions in use from 1977 levels" [11, p. IV-5]
- The production limitation "was chosen to achieve maximum international cooperation in the effort to contain CFCs," [11, p. IV-7]

From the above it is clear that EPA has wrongly prejudged many factual issues critical to the ANPR and therefore has circumvented the due process procedure:

- EPA has only solicited comments on the "appropriateness of restricting the use of CFCs" and the "feasibility of implementing one of two control strategies."
- EPA has been impervious to contrary evidence surrounding the ozone depletion by CFC theory by concluding that depletion is factual, not hypothetical.
- EPA has likewise made factual conclusions as to the results of depletion.

- EPA has signalled several possible approaches but has already decided on the production limitation approach.

- The actions of EPA have created a perception in the minds of the public that the "destructive" effects of CFCs and the subsequent "health hazards," are facts rather than conjecture.

HIMA believes that EPA should continue to seek international cooperation in studies to investigate stratopheric chemistry and the ozone depletion by CFC theory. However, the evidence above on prejudging only supports HIMA's contention that the ANPR should be withdrawn.

5. Regulation of CFCs Should Also Be Considered Only in Concert with Other Nations

The U.S. is the only country in the world attempting to regulate non-aerosol uses of CFCs. Moreover, the U.S. accounts for only one-third of global CFC emissions. Even if the "soft science" ozone depletion theory were correct as stated by EPA, the proposed U.S. action would produce little significant change in global emissions. This is because unilateral U.S. restrictions will create increased emissions from other nations as they benefit from the economic disadvantages imposed on U.S. industry. This is illustrated by the fact that other countries are moving at top speed to expand CFC production capacity. From this point of view, EPA's ANPR has already done a disservice to U.S. industries who use CFCs.

Overtones by the EPA, specifically by participation in international discussion groups, have resulted in almost no world-wide acceptance of the proposed U.S. controls. In fact, only three countries have issued a propellant ban. No other countries have even proposed a non-aerosol, Phase II-type ban of CFCs. Mindful of the controversial nature of the scientific theory, most nations have apparently been unwilling to surely sacrifice a segment of national economy for an unsure, unproven, and controversial scientific hypothesis. This is understandable and is, in fact, the HIMA position.

The way that the CFC issues relate to other nations is envisioned by HIMA as follows:

- No multinational activities should be considered until adequate measurement science has shown that the ozone depletion hypothesis is factual and that its predicted effects are confirmed.

- U.S. actions in response to the above should only be done in concert with a significant number of nations. Our recommendation is that U.S. activities in this matter be referred by President Reagan's Administration to the U.S. Ambassador to the United Nations.

To sum,

- EPA's proposal is not in concert with other nations.
- EPA has failed to convince other nations of the significance of this proposed regulation.
- EPA's premature proposal is conceived by other nations as one more opportunity to gain industrial economic advantage over the U.S.
- EPA should withdraw the proposal.

6. A Regulation That Artificially Creates CFC Shortages and Price Increases is Not in the Best Interest of the U.S. Health Care System.

The principal uses of CFCs by health care product manufacturers are detailed elsewhere (see page 11). An analysis by Rand Corporation conducted under an EPA contract confirms the fact that a production cap would result in CFC shortages and higher prices. [29] This approach is totally unfair to the American public who deserve and expect quality health care at reasonable costs. It is believed likewise totally unfair to industries who use CFCs in the manufacture of health care goods.

Table 1 shows the cost changes for hospitals that would occur as a result of increased prices anticipated with the restriction of the use of CFCs.

For smaller sterilizers using 25# cylinders of EtO-CFC gas mixtures, the increased cost is 444%. For larger sterilizers using 140# cylinders, the increased cost is 266%.

The significantly increased cost due to the CFC component may result in a reduction in the use of this important sterilization system -- particularly by hospitals. As mentioned earlier, this may result in less than satisfactory sterilization.

During the past few years, rising health care costs have been of concern to all citizens; the government and the private sector have taken many steps attempting to limit the rate of increase of such costs. If manufacturers of essential health care items are required to compete for available CFC supplies and to pay ever-increasing prices, a totally unnecessary addition to the nation's health care bill will result. Manufacturers will find it necessary to pass cost increases on to the American public.

TABLE 1

EFFECT OF HIGH COST OF CFCs ON STERILIZER CYCLE OPERATIONS

			HOSPITAL CURRENT 12/88 COST/CYCLE		RESTRICTED 12/88 COST/CYCLE	
CHAMBER DIMENSIONS (INCHES)	CHAMBER FT^3	CYCLE LBS OF GAS @ 0.4 LB/FT^3	@ 2.25/LB* 25# CYLINDERS	@ 0.90/LB* 140# CYLINDERS	@ 6.00/LB 25# CYLINDERS	@ 4.00/LB 140# CYLINDERS
10x16	0.71	0.28	0.63	0.25	1.68	1.12
10x36	1.60	0.64	1.44	0.58	3.84	2.56
16x16x26	3.85	1.54	3.47	1.39	9.24	6.16
20x20x38	8.80	3.50	7.92	3.17	21.12	14.08
24x36x36	18.00	7.20	16.20	6.48	43.20	28.80
24x36x48	24.00	9.60	21.60	8.64	57.60	38.40
24x36x60	30.00	12.00	27.00	10.80	72.00	48.00
28x67x52	56.40	22.50	TANKS TOO SMALL	20.25	TANKS TOO SMALL	90.00
28x67x78	84.60	33.80	"	30.42	"	135.20

*Average Costs

An even greater injustice to the health care system will result if CFC shortages affect the availability of esential health care supplies. Manufacturers of medical devices and diagnostic products lack the ability to change product ingredients and manufacturing methods without appropriate approvals by the Bureau of Medical Devices of the Food and Drug Administration. Such approvals require the development of data proving product safety and efficacy. It is possible that nonavailability of CFCs to medical device manufacturers and the inability to find FDA approved substitutes will result in curtailment of the production of some essential medical supplies.

Therefore, we urge the Agency to pay particular emphasis to the health care aspects of Phase II controls of CFCs. We invite the Agency to meet further with us to discuss the essential nature of CFCs to the medical products industry. We also urge the Agency to withdraw its ANPR due to its potentially devastating effect on the health care system.

7. Suitable Substitutes for CFCs Used by the Medical Device Industry Are Not Presently Available

Suitable CFC substitutes for use by the medical device industry would have to meet two kinds of criteria:

1. They would have to reduce the potential for the theoretical depletion of ozone in the stratosphere by:
    - a. Being a less stable molecule unable to survive the journey to the stratosphere, but not so unstable as to contribute to smog, or
    - b. Being a CFC that does not contain chlorine; e.g., fluorine is not involved in the ozone depletion mechanism.
2. They would have to display all of the properties of low-toxicity, low residue formation, and biocompatibility as the CFCs presently used with medical devices, and be non-flammable, have similar boiling points and heat transfer characteristics, and be low in cost.

In March 1980, the DuPont Company provided EPA with a summary of research done to develop commercially acceptable alternatives to present CFCs. The CFCs that would be restricted by the EPA proposal are shown in Table 2.

TABLE 2

CFCs PROPOSED TO BE RESTRICTED BY EPA

Number	Formula	Boiling Point °F/ Vapor Pressure, psia at 70°F	Non-Aerosol Commercial Uses			
			Refrigerant	Blowing Agent	Cleaning Agent	Other
CFC-11	CCl_3F	75°/13 psia	✓	✓	Limited	—
CFC-12	CCl_2F_2	−22°/85	✓ (b)	✓	—	(c)
FC-22	$CHClF_2$ (d)	−41°/136	✓ (b)	—	—	—
CFC-113	$CCl_2F\ CClF_2$	118°/6	✓	—	✓	—
CFC-114	$CClF_2\ CClF_2$	39°/28	✓	✓	--	—
CFC-115	$CClF_2\ CF_3$	−38°/120	✓ (b)	—	—	—
Halon 1301	$CBrF_3$	−72°/210	Limited	—	—	(e)

(b) Also component of refrigerant azeotropic mixtures.
(c) Direct contact liquid food freezant (CFC-12) and inerting agent for ethylene oxide sterilant gas.
(d) Only major commercial hydrochlorofluorocarbon.
(e) Fire extinguishant (Halon 1301).

In addition to the criteria for substitutes mentioned above, DuPont points out that a commercial manufacturing process must exist or be developed.

DuPont's report to EPA provided information on fourteen candidate fluorocarbons that were investigated as potential substitutes. These are shown in Table 3.

Of the compounds listed in Table 3, DuPont reported that only FC-22, -134a, -141b, -142b, and -152a have survived the tests performed to date. However, for none of these compounds are the results of long-term toxicology studies yet available. Only FC-22 is a major commercial product; FC-142B and -152a are manufactured only in very limited quantities. The reasons for discontinuing work on other candidates are shown in the Table 3.

As to the suitability of the five candidate chemicals for medical device manufacture applications, three of the compounds (FC-22, -141b, and -142B) are classified as weak mutagens and, therefore, are totally unacceptable. Chemical -152a has low toxicological properties and information on -134a is incomplete. Probably none of these potential substitutes could be used by the medical device industry.

DuPont also pointed out that no commercial production process for FC-134a or FC-141b presently exists. In addition, seven to ten years may be necessary to reach commercial production for most alternatives.

TABLE 3

ALTERNATIVE CFC COMPOUNDS

Number	Formula	Boiling Point, °F	Potential Application	Flammable	Manufacturing Process	Toxicology
FC- 21	$CHCl_2F$	48	Blowing Agent	No	Yes	Toxic (b)
22	$CHClF_2$	−41	Refrigerant	No	Yes	Weak Mutagen (c)
31	CH_2ClF	16	Propellant	Yes	NC	Toxic (b)
32	CH_2F_2 (a)	−61	None (b)	Yes	NC	Low
123	$CHCl_2CF_3$	82	Blowing agent, refrigerant	No	No (b)	Low
124	$CHClFCF_3$	12	Refrigerant, other	No	No (b)	Low
125	CHF_2CF_3 (a)	−55	Refrigerant	No	No (b)	Not Known
132b	$CH_2ClCClF_2$	116	Cleaning agent-too aggressive (b)	No	No	Very Incomplete
133a	CH_2ClCF_3	45	Blowing agent, propellant	No	NC (US)	Embryotoxic (b)
134a	CH_2FCF_3 (a)	−16	Refrigerant, other	No	No	Very Incomplete (testing in progress)
141b	CH_3CCl_2F	90	Blowing agent	Yes	Yes (d)	Weak Mutagen
142b	CH_3CClF_2	14	Blowing agent, refrigerant	Yes	Yes	Weak Mutagen (c)
143a	CH_3CF_3 (a)	−54	Refrigerant	Yes	NC	Incomplete
152a	CH_3CHF_2 (a)	−13	Propellant, refrigerant	Yes	Yes	Low (c)

(a) Contains no chlorine.
(b) Work discontinued principally for this reason.
(c) Long-term toxicity test in progress.
(d) Developmental process only.
NC--Not Commercial.
NC(US)--Not Commercial in United States.

With respect to any substitutes for the medical products industry, three considerations must be made:

1. The use of non-CFC propellants (such as butane) results in the non-delivery of a good portion of the product to be delivered (the butane gas escapes before all the product is released). This is not a problem with CFCs.

2. The use of CFC substitutes as solvents for medical device cleaning may require an elaborate solvent system. Where a cleaning process is currently using three solvents, the loss of CFCs may necessitate the use of up to 20 solvents to achieve the same results. These elaborate systems, using a variety of solvents (some possibly with questionable toxicological properties), will also create environmental and waste disposal problems. The reactivity between the solvents and the medical devices must also be considered.

3. Capital investment in developing substitutes will be enormous and not necessarily successful.

Based on the above, HIMA concludes that suitable CFC substitutes for the medical device industry do not exist.

8. Even if CFC Substitutes Can be Developed, FDA Requirements May Preclude Their Use or Require Unacceptable Costs

Manufacturers of medical device and diagnostic products are keenly aware that their products are frequently involved in life-and-death situations and that the effectiveness, purity, sterility, and other properties of their products are all important to the providers of health care and to the public in general. The exacting requirements in material control, quality, labeling, and packaging mean that medical product manufacturers are extremely sensitive to known or unknown changes that could affect the safety and efficacy of their products. In 1976 the Medical Device Amendments to the Food, Drug and Cosmetic Act created the authority for formalizing all controls on medical devices under the Bureau of Medical Devices of the Food and Drug Administration. Thus, our industry today is tightly regulated by FDA to the extent that EPA's proposal on CFC controls is unworkable, unfair, costly to the health care system, and may result in problems with the safety and efficacy of products.

To deal first with substitutes, HIMA maintains that EPA is obligated to carefully evaluate its proposal as regards FDA regulation and the medical device industry's obligation to the American public. Our presentation beginning on page 11 discusses the specific uses of CFCs in our industry. We also present information on suggested alternatives to CFC use. To more specifically speak to this problem, we present below the various FDA regulatory aspects that could be involved in the evaluation of any suggested CFC substitute.

1. New clearance - will the substitution create a "new" product for which a premarket approval submission to FDA is required prior to marketing? Such approvals typically require several years of preclinical and clinical research with the costs per product ranging from $500,000 up. Regardless of the cost, will the result prove satisfactory and will the FDA approve?

2. Essential equivalency - if a premarket approval is avoided, will a submission for essential equivalency to existing product (e.g., using a CFC) be required? Will it be possible to prove that the substitute is in all ways equivalent to the CFC and that, therefore, the product is the same?

3. Good manufacturing practices (GMPs) are specificed by FDA in finite detail. As an example, our industry is required by FDA to establish specific GMPs for each product and to justify any deviation from the specification. What ramifications will result from

the introduction of a suggested CFC alternative on the GMP aspects of our compliance requirements to the FDA must be determined. If the suggested substitute is not volatile, is flammable, is explosive, affects tensile strength, affects product elongation, affects product ductility, etc., what will be the effect on the ability of the company to establish and maintain GMPs?

It is apparent that any action by the EPA will greatly affect the ability of our companies to maintain and bring new products to the market and to serve the American health care system.

9. The Proposed Mandatory Controls and Economic Incentives Approaches Are Not Workable and Will Selectively Impact U.S. Industry to the Advantage of Foreign Industry

EPA's proposal to auction permits allowing the right to use or produce CFCs is replete with serious problems and unfair limitations on the medical device industry. For example, users and producers will view any periodic redistribution of CFCs as disastrous from a business point of view. No sound business can operate with supply uncertainties as would be created by the permit approach. The tendency for some businesses will be to hoard permits to insure a supply of CFCs. Producers of CFCs would also face unfair and burdensome decisions. Can they be expected to maintain production capabilities in the face of a possible on-again, off-again situation controlled by the ability to obtain permits? Certainly it is likely that some CFC manufacturers would simply remove CFCs from their product lines. This in turn could result in loss of jobs and product shortages. Manufacturers of CFCs as well as those using CFCs in product production may find it best to move plants to overseas locations.

The EPA's selling of permits will also generate revenue. HIMA believes this to be an inappropriate EPA activity, since revenue generation is an authority vested in the Congress. Moreover, because EPA in its proposal seems to assume ownership of production or use rights, the EPA is clearly providing unwanted government intrusion into the marketplace and free enterprise system.

As limits are placed on production of CFCs, costs will rise sharply. U.S. based medical device manufacturers, faced with CFC cost increases and shortages, would be unable to compete with foreign manufacturers in two ways.

First, as prices of CFCs increase, production costs increase and are passed on to hospitals. In an effort to contain costs, hospitals will purchase foreign made products. American manufacturers would lose market share because of increased imports of foreign medical products.

Second, U.S. manufacturers will be at an unfair disadvantage in maintaining overseas markets. American manufacturers would lose foreign market share because of decreased exports of medical products.

The cost burden placed on domestic manufacturers by the proposed regulation is the direct result of increased manufacturing costs with no increase in productivity. In an effort to cut costs, some U.S. medical device firms may move some plants to locations outside the U.S., causing a loss of jobs and widening gaps in unfavorable trade balances.

At a time when the United States is facing strong competition from foreign competitors (countries who encourage CFC use in products) in a variety of markets, it is inconceivable that the EPA would propose a regulation that could place U.S. companies at a greater competitive disadvantage.

10. EPA Has Failed To Evaluate The Benefits and Essential Nature of CFCs To The Health Care System

CFCs are essential to the medical device industry because:

1. Satisfactory alternatives do not presently exist.

2. FDA regulations for safety and efficacy of products could prevent the use of alternatives.

3. Any limitations on CFC use will affect the flow of goods to the health care system.

Although not a major user of CFCs in terms of percent of annual production, the medical products industry has the obligation of providing a constant supply of essential goods to the health care system. The EPA has failed to consider our responsibility to the American people by not studying all of the direct and indirect consequences of CFC production limitations. In addition, other consequences such as pain, suffering, and fatalities will result from an interruption in the flow of goods.

CFCs are essential to the health care system. The proposed regulation, which would limit their availability to our industry, is ill-conceived, unfair, and non-workable. Most important, however, is the proposal's imminent danger in jeopardizing the health of every American.

11. The EPA Has Failed To Recognize The Role of CFCs In Energy Conservation

A report on the "Energy Consequences of Chlorofluorocarbon Regulation" by Battelle Columbus Laboratories [30] provides estimates of energy penalties that would be associated with a hypothetical ban on CFCs in auto air conditioning, home and store refrigerators, insulating foams, and liquid food freezants. Although a total ban is not contemplated by EPA, the analysis serves to demonstrate energy-saving contributions resulting from the use of CFCs. The report concludes that a ban on CFCs in the United States would result in a net energy penalty in the 10th year equivalent to almost 10 billion gallons of fuel, and to as much as 50 billion gallons of fuel over the first decade.

Medical device manufacturers will also experience an energy penalty. Substitute solvent systems, which undoubtedly would use a greater number and variety of solvents, would require more energy to evaporate/dispose of spent solvents. Sterilization cycles, increased in time by the use of substitute gas mixtures, will also require greater inputs of energy. The increased energy costs will ultimately be passed on as increased prices in medical products.

CFCs possess a variety of desirable qualities. It is these qualities that directly affect energy usage. Therefore, Phase II controls on CFCs would place a significant energy burden on the medical products industry.

12. EPA Has Failed To Perform Certain Pre-ANPR Requirements

These requirements relate either to provisions of the Clean Air Act, 42 U.S.C., para. 7457, or the Toxic Substances Control Act (TSCA), 15 U.S.C., para. 2605. Both types of requirements are included herein because, in the ANPR, EPA is not certain as to the authority it would use in attempting Phase II CFC controls. Specifically, the Agency said it intended to regulate pursuant to Section 157 of the Clean Air Act, unless requisite findings are made that it would be in the public interest to regulate instead under TSCA.

Clean Air Act Preconditions

When, in 1977, Congress added sections 150-159 (the so-called ozone provisions) to the Clean Air Act, it did so by recognizing the tenuous nature of two scientific issues:

1. is the ozone depletion theory true? and, if so,

2. would the depletion actually endanger our planet?

Thus, the fact that the language of Section 157 provides a two-fold test to justify regulatory action is all important. Specifically, CFCs must "... reasonably be anticipated to affect the stratosphere, especially ozone in the stratosphere," and that these effects "... may reasonably be anticipated to endanger public health or welfare."

HIMA maintains that reasonable degrees of certainty that constitute preconditions under Section 157 have not been met. While we do not herein review in detail the legislative history surrounding Section 157 and the question of validity statements by the Congress, it is appropriate to point to at least one statement in the Congressional Record (172 Cong. Rec. at 13510-11) that expresses the intent of Congress. CFCs are recognized as "... a group of extraordinarily useful chemicals, ..." and it "... would be ill-advised to disrupt what has become a major industry in this country, purely on the basis of an unproven hypothesis."

With regard to the Clean Air Act, its provisions and legislative history, HIMA concludes that EPA has not met, and cannot now meet, the preconditions of CFC regulation that require that CFCs must "... reasonably be anticipated to affect the stratosphere, especially ozone in the stratosphere" and that effects "... may reasonably be anticipated to endanger public health or welfare."

Why does HIMA emphasize the Clean Air Act requirements? We do so because we believe that the Agency has not met the mandate of Section 157(b) of the Act that requires EPA to consider all the research and studies called for under Sections 153 and 154 of the Act. In issuing the ANPR, it would appear that EPA intends to regulate on the basis of the NAS studies dealing only with CFC-11 and -12 in spite of this requirement. Section 153(a) of the Act specifically directs EPA to study the "... cumulative effect of all substances, practices, processes and activities which may affect the stratosphere, especially ozone in the stratosphere." It is clear that the EPA has not met these requirements in that it has:

1. Not adequately considered studies on CFCs by the United Kingdom (UK) [6] and the Commission of the European Communities (EEC) [7] whose conclusions differ from those of the NAS study. The results of the UK and EEC reports prevent EPA from establishing a "reasonable anticipation" of stratospheric ozone depletion and resulting endangerment.

2. Not considered other substances, practices, and processes that could positively or negatively affect the ozone layer.

Preconditions for TSCA

The ANPR indicates that EPA may rely, in part, on Section 6 of TSCA, 15 U.S.C., para. 2605, as authority for any final regulation. HIMA considers that the TSCA preconditions would be:

1. For each compound, or major category, or use of that compound, EPA must establish a reasonable basis to conclude that use of the compound results in an unreasonable risk of injuring health or the environment.

2. For each compound, the Agency must establish that it has selected the least burdensome requirements necessary to reduce the risk.

3. As part of establishing "unreasonable risks" for each compound the EPA is required to study and publish analyses of costs and benefits including effects on the national economy, small businesses, and technological innovations.

4. EPA must also establish the benefits and risks of substitutes for each of the various uses of CFCs.

It is evident that the EPA has not met the preconditions that would be required under TSCA because:

1. Each compound (e.g., CFC) and each major category of use has not been investigated adequately enough to provide a reasonable basis for establishing to an "unreasonable risk." In fact, an August 1980 study, partly sponsored by EPA (the "Bailey Report") [31], states that the risks of delaying regulation several years would be relatively small and that such risks would be outweighed by the societal costs attributable to overregulation. The report concluded that there was both time, and a great need for further research on the ozone-depletion theory.

2. EPA has not shown for each CFC that it has selected the least burdensome requirement needed to reduce the risk. The risk is not established per CFC and no consideration of how burdensome the proposal would be to the health care system has been considered.

3. Adequate analysis of costs and benefits has not been conducted. Specifically, the EPA has little understanding of the essential nature of CFCs in the medical device industry and the consequences to the health of Americans that would result from the proposed rulemaking.

4. Because no feasible substitutes exist for the uses of CFCs in the medical device industry, it is not possible to establish the benefits and risks from the use of these substitutes.

Therefore, HIMA concludes that the EPA has not, and cannot, satisfy the pre-regulation requirements under either or both of the statutes it could use as authority for the proposed regulation.

13. EPA Has Failed to Conduct All The Investigations Needed Before Further Regulation of CFCs

These needed investigations are:

- Economic analyses - These should include both short and long-term consequences of the ANPR. The Rand report is inadequate for this purpose.
- Environmental impact statement - This is required by the National Environmental Policy Act (NEPA) and applicable guidelines of the Council on Environmental Quality.
- Executive Order 12044 - This requires EPA to prepare a regulatory analysis of the ANPR and significant alternative regulatory approaches.
- Regulatory Flexibility Act - This requires EPA to consider regulatory alternatives having the least impact on small businesses. Moreover, it is required that small businesses be made aware of proceedings and given an adequate opportunity to participate.
- Precondition for TSCA as regulatory authority - If TSCA is used, the EPA must comply with all the requirements of that Act, including the cost-benefit analysis (previous section).
- Precondition for Clean Air Act as regulatory authority - If this is used, the EPA should have published an economic impact assessment before issuing a proposed rule. EPA is also required to take feasibility into account in its decision-making (previous section).
- Effects of other ozone depletion mechanisms - EPA should, but has not, adequately studied other mechanisms or chemicals that could add to or deplete the ozone layer.

I. HIMA'S RECOMMENDATIONS REGARDING THE ANPR

1. Withdraw the ANPR

In light of the above, we propose that the best interest of the American public and the medical device industry will be served if the EPA withdraws the ANPR. Justification for this action is included in our evaluations. We do not believe that the American public, the Congress, nor industry should be forced to suffer the real consequences of the proposed regulation, which is based on a scientifically disputed theory of CFC-caused ozone depletion and unsubstantiated theories of subsequent damage. Even if the theories are true, coordinated international action to protect the world's biosphere will occur only following the development of adequate non-controversial scientific facts.

2. Sponsor Adequate Scientific Investigations

After withdrawal of the ANPR, the Agency should spearhead an international cooperative effort to investigate the validity of the ozone depletion theory by means in addition to computer models. It will be necessary to base the effort in part on actual measurements of ozone in the stratosphere over time.

In anticipation that there will be international acceptance of the risk of continued CFC use, EPA should also promulgate and/or encourage research in the development of alternative chemicals and/or processes that will be adequate substitutes for present CFC applications.

3. Exemptions for Medical Product Uses

If some further regulation of CFCs issues in spite of the above recommendations, HIMA requests that EPA exempt health care uses of CFCs and take steps to ensure an adequate supply to the health care industry at non-inflated prices.

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Part IX

Environmental Protection Agency

Ozone-Depleting Chlorofluorocarbons; Proposed Production Restriction

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 762

[OPTS-42008 (TSH-FRL 1606-6)]

Ozone-Depleting Chlorofluorocarbons; Proposed Production Restriction

AGENCY: Environmental Protection Agency (EPA).

ACTION: Advance notice of proposed rulemaking.

SUMMARY: Because of the destructive effect of chlorofluorocarbons (CFCs) on stratospheric ozone, EPA is considering restricting their production such that the potential for ozone depletion does not increase over present levels. Two major approaches to CFC emissions control are being considered: a Mandatory Controls Approach and an Economic Incentives Approach. The first would limit CFC production through mandatory controls or technology based standards. The second would limit CFC production through the distribution of marketable permits. Several options are being explored for the implementation of these strategies.

EPA solicits comments on the appropriateness of restricting the use of CFCs and on the feasibility of implementing the Mandatory Controls and Economic Incentives Approaches.

DATES: Written comments on or before January 5, 1981.

ADDRESS: Written comments should be sent to the Technical Information Specialist for this Advance Notice of Proposed Rulemaking: Joni T. Repasch, Office of Pesticides and Toxic Substances (TS-793), Environmental Protection Agency, Room E-447, 401 M St., SW, Washington, D.C. 20460, (202-755-8050).

FOR FURTHER INFORMATION CONTACT: Gordon R. Olson, Office of Pesticides and Toxic Substances (TS-794), Environmental Protection Agency, 401 M St., SW, Washington, D.C. 20460, (202-755-1280).

SUPPLEMENTARY INFORMATION:

I. Ozone Depletion and the Need for Regulatory Control
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III. A Summary of Issues on which Comments are Requested.

I. Ozone Depletion and the Need for Regulatory Control

A. Introduction

Chlorofluorocarbons (CFCs) are a family of chemical compounds suspected of depleting stratospheric ozone. When ozone concentration is reduced, increased amounts of damaging ultraviolet light (DUV) are permitted to reach the earth's surface. This may have a number of harmful consequences, including higher incidence of skin cancer, decreased crop yields for several important species and adverse effects on the marine food chain.

In March of 1978 the Environmental Protection Agency and the Food and Drug Administration banned CFCs as propellants in nonessential aerosol uses (ref. 1). Several other nations have also already acted to restrict aerosol propellant applications of CFCs. However, continued world emissions of CFCs are still considered a significant and increasing threat to human health and the environment. The temporary emissions reduction achieved by the actions of the United States and other nations regarding CFC aerosol propellants has been nearly eliminated by rapid growth of CFC usage in nonaerosol applications in the United States and abroad, and by continued aerosol use in nations which have as yet taken no control actions.

At present there are five domestic producers of CFCs. The overwhelming percentage of CFC emissions occur in use rather than in manufacturing—approximately 98 percent and 2 percent, respectively—so the regulations are directed at controlling emissions in the various CFC applications.

The major non-aerosol uses of CFCs in the United States are:

1. As a refrigerant in mobile air conditioning units used in passenger vehicles;
2. As a solvent, primarily in industrial cleaning, drying, and solder flux removal applications;
3. As the blowing agent for closed-cell rigid foams, used in insulating and packaging applications;
4. As the blowing agent for open-cell flexible foams, used in bedding, furniture, automobile seat cushions, and carpet underlay;
5. As the refrigerant for large industrial and commercial chillers, home refrigerators, freezers and air conditioners, and retail food store refrigerators; and
6. In numerous miscellaneous uses such as liquid fast-freezing of food and hospital instrument sterilization.

Use of CFCs worldwide is projected to increase substantially over the next decade. Production of CFCs in the United States is expected to grow at a 7 percent annual rate (in the absence of any further regulation), from 600 million pounds in 1980, to 1.2 billion pounds in 1990, according to the report on CFC control written for EPA by the RAND Corporation. (ref. 2) Total world emissions, in the absence of any further regulation, are projected to grow at a 9 percent annual rate over the next decade, from 1.5 billion pounds in 1980 to 4.5 billion pounds in 1990, according to EPA analysis of data collected for the Chemical Manufacturers Association. (ref. 3)

The objective of Agency action is to limit CFC use in all applications such that the potential for ozone depletion does not increase over present levels. The proposed action will recognize the differential impact that individual CFC compounds have on ozone depletion (see Permit Pound Concept, Section II.B.2.a., below).

EPA is considering two major approaches to CFC control. The first is a Mandatory Controls Approach. This would put an indirect ceiling on CFC use through mandatory controls or technology-based standards. Three options for implementing these controls are discussed in Section II B 1. The second major approach is an Economic Incentives Approach. This would put a ceiling on total production, and be implemented through a system in which marketable rights to CFCs are distributed. Three different options for allocating these rights are discussed in Section II B 2. Based upon presently available information, EPA believes the latter approach to be a more efficient method of reducing the environmental and human health risk. The merits of each approach are discussed in more detail later.

This regulatory action would constitute the first United States control on CFCs since the ban on nonessential aerosol propellant uses that was promulgated jointly by EPA and the Food and Drug Administration in March 1978. EPA solicits comments on the approaches, options and issues presented in this advance notice of proposed rulemaking.

EPA Phase II CFC regulations will be promulgated under the authority of Section 157 of the Clean Air Act, as amended, (42 U.S.C. 7450–7459), unless EPA finds under Section 6(c)(1) and Section 9(b) of the Toxic Substances Control Act (TSCA) (15 U.S.C. 2601) that it is in the public interest to use TSCA instead of the Clean Air Act.

B. A Summary of the Ozone Depletion Theory

The ozone layer is located in the stratosphere, 10 to 50 kilometers above the earth's surface. It is important to the natural environment because it prevents the more damaging wavelengths (290–320 nm) of solar radiation—those not screened out by other atmospheric constituents—from reaching the earth.

The concentration of ozone present in the stratosphere is determined by a dynamic balance between naturally occuring photochemical reactions producing it and other chemical processes destroying it. The rate of destruction of ozone is influenced by the presence of several chemical species containing hydrogen, nitrogen, or chlorine.

In view of the vital screening function of the ozone layer, any significant increase in the rate at which chlorine species are injected into the stratosphere should be of concern, because chlorine and chlorine oxide act as catalysts in certain reactions that destroy ozone. Two University of California scientists theorized in 1974 that CFCs slowly migrate to the stratosphere where they are photolytically disassociated, releasing free chlorine. The continued worldwide release of CFCs is therefore troublesome, it appears to significantly increase the chlorine concentration in the stratosphere and this in turn leads to ozone depletion. EPA has relied primarily upon the scientific analysis of the National Academy of Sciences (NAS) for support of this theory as well as for an assessment of the potential hazards posed by continued world emissions of CFCs.

Global CFC emissions are not large compared to the emissions of other chlorine-containing chemical compounds, but these other compounds are for the most part quickly destroyed or otherwise removed in the troposphere so that only a small percentage of ground-level emissions reach the stratosphere. In contrast, CFCs are very resistant to removal in the troposphere, so that most of the CFCs emitted at ground level eventually reach the stratosphere where, in the presence of more intense and shorter-wavelength ultraviolet light, they are decomposed and release chlorine.

To better quantify the predicted effects of CFCs on ozone concentrations, several research groups around the world have undertaken computer simulations of the relevant atmospheric chemistry and physics. Because of the complexity involved in closely simulating such large-scale natural systems, simplifications have been introduced into these models. The most significant simplification has been to consider variations in the concentrations of chemical species only along the vertical dimension (altitude), assuming perfect mixing along the longitudinal and latitudinal dimensions. These are the so-called One-Dimensional Models (1-D Models).

The basic function of the 1-D Models is to solve a complex set of differential equations, providing vertical profiles of species concentrations at any moment in time. Included in the models are a large number of chemical reactions believed to be occurring in the atmosphere. The chemical reaction rate coefficients and the photolysis rate coefficients (measures of the speed with which reactions occur), the vertical diffusion coefficients (a measure of the speed of vertical transport), and other parameters needed to produce a numerical solution have generally been measured either in the field or in the laboratory. A few are estimates. The inputs to the models are based on both historical and predicted future annual emissions of CFCs at the earth's surface.

NAS used such a model to calculate future effects on the ozone concentration of various emissions scenarios for CFMs.[1] The four scenarios NAS considered all use the same historical emissions data, but differ in their predicted future emissions:

Scenario A assumes that future emissions would be fixed at 1977 levels;

Scenario B assumes that future emissions would remain at 1977 levels until 1983, when a reduction of 25 percent would occur, and that emissions after 1983 would remain fixed at that lower level;

Scenario C is identical to B, except that an additional 25 percent step reduction is assumed to occur in 1988—emissions after 1988 would then remain fixed at this new level;

Scenario D assumes that emissions would grow at 7 percent a year until 2000, and then remain constant.

For these four scenarios, NAS predicts the following percentages of ozone depletion:

Table 1.—*Predicted Percent Ozone Depletion* [1]

Scenario	In 20 years (1999)	In 50 years (2029)	Steady-state [2]
A	6.1- (±4.2)	10.0- (±7)	16.5- (±11.5)
B	5.6- (±2.8)	8.0- (±6)	12.3- (±8.3)
C	5.2- (±3.5)	6.0- (±4)	8.4- (±5.8)
D [3]	8.0	28.0	57.0

[1] CFMs only.

[2] The steady-state gives the limiting equilibrium value for ozone depletion, and is equivalent to base year + about 100 years (theoretically infinite).

[3] Error ranges are not provided for this scenario, nor are the average values for ozone depletion corrected for temperature and water-vapor feedbacks or tropospheric sinks.

Source: National Academy of Sciences.

NAS also estimated that historical emissions of CFMs may have already led to an ozone depletion of 2.1 (±1.5) percent.

C. The Risks of Continued World Chlorofluorocarbon Emissions

The National Academy of Sciences issued two sets of reports on this subject in 1976 and 1979. As shown above, the latest reports of the NAS, issued in November and December, 1979 (ref. 5, 6) conclude that continued world CFM emission at 1977 rates would eventually result in ozone depletion of about 16.5 percent (with a 95 percent probability that the eventual level would fall in the range from 5 to 28 percent depletion). One-fourth of this depletion would occur within 15 years, and one-half within 35 years. NAS also concludes that if emissions were to continue to increase between 1980 and 2000 by 7 percent annually, instead of leveling off at 1977 levels, there would be a 75 percent probability that ozone depletion would eventually exceed 30 percent (ref. 6, p. 99). Other studies report estimates of ozone depletion that differ somewhat from these in the NAS study, but that fall within the confidence interval of the NAS study.

Ozone depletion would substantially increase the average intensity of biologically damaging ultraviolet light (DUV) reaching the earth's surface. This increase could be as high as 44 percent at mid-latitudes for an ozone depletion of 16 percent. Such increases would be highly detrimental both to human health and to nonhuman biological systems.

Assuming continuation of present patterns of sunlight exposure, NAS predicts that a 16 percent ozone depletion would result in several hundred thousand additional cases of nonmelanoma skin cancer annually, and, with somewhat less certainty, in several thousand additional cases of melanoma skin cancer (often fatal) annually in the United States alone (ref. 6, p. 6). A relationship has been epidemiologically established between increased DUV exposure and incidence of non-melanoma skin cancer (ref. 8). For nonmelanoma skin cancer, approximately a four percent increase in incidence can be expected for every one percent increase in ozone depletion on the average. For melanoma, this statistical relationship is less certain, but appears to be about two to one. (ref. 6, p. 99).

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[1] CFMs, or Chlorofluoromethanes, are a group of chemicals within the CFC family, which NAS considered because two of them, trichlorofluoromethane (CFC-11) and dichlorodifluoromethane (CFC-12), make up greater than 90 percent of world CFC production.

Other significant effects of increased DUV may include reduced crop yields from many important agricultural species, including tomatoes, sugar beets, and corn (ref 6, p. 67); significant larval and juvenile killings of certain seafood species including anchovies, mackerel, shrimp and crab (ref. 6, p. 69); and adverse effects on the microorganisms constituting the base of the marine food chain. These and other environmental effects could be potentially more serious than the effects of ozone depletion upon human health. In addition, continued accumulation of CFCs in the lower atmosphere (troposphere) may induce a slight warming of the mean global surface temperature, but this is less than the warming predicted for a doubling of atmospheric carbon dioxide caused by fossil fuel combustion.

D. Rationale for Including All CFC's

NAS examined only two CFCs, CFC-11 (trichlorofluoromethane) and CFC-12 (dichlorodifluoromethane) because they represent the vast majority of all CFCs produced. NAS also briefly considered CFC-22 (chlorodifluoromethane), but excluded it from the analysis because, as a partially halogenated compound, its likelihood of reaching the stratosphere before dissociating is much less than that of fully halogenated compounds. However, the findings by NAS on the ozone depletion potential of CFC-11 and CFC-12 are relevant qualitatively for all chlorofluorocarbons.

EPA believes that any regulation of ozone depleters should be as comprehensive as possible, consequently this regulation would address all CFCs.

Potential ozone depleters found outside the CFC chemical family may eventually require regulatory action as well. However, the present set of regulations would be limited to CFCs only because there does not exist sufficient information on other ozone depleters, and because the long lifetime in the troposphere of CFCs makes them particularly suspect of increasing the concentration of chlorine in the stratosphere.

The proposed regulatory action would cover chemicals with the following general formula:

$C_nCl_xF_yH_{2n+2-x-y}$; $x>0$, $y>0$

This formula characterizes all alkanes that contain at least one chlorine *and* one fluorine, including CFC-11, CFC-12, CFC-113, CFC-114, CFC-115, and CFC-22, as well as several other CFCs not presently manufactured or manufactured only in very limited quantities. The proposed regulatory action intends to take into account the differing ozone depletion potential of the various CFC compounds. EPA is considering including the bromofluocarbons at a later date if future research substantiates the initial NAS finding that bromine is as effective an ozone depletor as chlorine. (ref. 6, p. 193) EPA solicits comment on this approach to classification of CFCs.

E. CFCs as an International Problem

Ozone depletion truly is a global problem. Regardless of where CFCs actually are emitted, tropospheric mixing results in worldwide CFC distribution with some small differences between the hemispheres caused by the transport from Northern Hemisphere sources to the Southern Hemisphere. Therefore, the danger presented by all CFCs emitted will be spread around the globe. This means that any damage caused by CFC emissions will not be limited within the boundaries of the source country.

The use and production of CFCs are widely distributed around the world, as shown by Table 2.

Table 2.—*World Chlorofluorocarbon Production and Use—1977*

Nation	Percent of total world	
	Use	Production
United States	35.8	39.8
EEC [1]	30.2	38.1
Japan	6.5	7.3
Others [2]	27.5	14.8
Total	100.0	100.0

[1] European Economic Community manufacturers of CFCs are, in decreasing order, Federal Republic of Germany, France, Great Britain, Italy, and The Netherlands.

[2] Other world manufacturers are, in decreasing order, the Communist Bloc, Canada, Australia, Spain, Mexico, Argentina, Brazil, South Africa, India, Israel, Greece, and Venezuela.

Source: EPA analysis of RAND Corporation and CMA data.

As is evident from the above data, no single nation accounts for a large enough portion of world use or production to be able unilaterally to control ozone depletion. If CFC use increases as forecast (about 9% annually), even the United States, which presently represents about one-third of the world market, can have only a small impact in limiting ozone depletion, when acting alone. The limited impact of a unilateral United States reduction (assuming this 9% annual growth) is shown in Table 3.

Table 3.—*Percentage Ozone Depletion Projected Under 3 Growth Scenarios* [1]

Regulatory option (action taken in 1980)	Contribution toward steady-state ozone depletion (in percent)		
	United States	Rest of world	Total
I. No action; uncontrolled growth until 1990	7.5	24.5	32.0
II. Freeze on Production (1980 levels) U.S. only	4.5	24.5	29.0
III. Significant Reductions (70 percent from 1980 levels U.S. only	1.5	24.5	26.0

[1] Assumes that emissions continue indefinitely at 1990 levels.

Source: EPA analysis of Lawrence Livermore Laboratory modeling.

II. Approach to Chlorofluorocarbons Control

A. Choosing a Strategy

To protect health and environment in the United States, EPA both must use its ability to regulate domestic CFC activities and must actively encourage other nations to take similar control actions. Domestic reductions without corresponding international action would be insufficient. Accordingly, the U.S. domestic emissions reduction strategy *must* be chosen not only on the basis of a balancing between risk to the U.S. health and environment (including the relative risk of CFC substitutes), and economic costs, as the law requires, but also on the basis of what effect the choice will have on other nations' decisions in this area. EPA considers that there are three general strategies which it could adopt regarding future emissions.

1. *Wait-and-see*—The United States takes no action until better evidence of the ozone depletion theory is obtained.

This is the least economically burdensome strategy in the short term, since it would avoid the administrative and resource costs imposed by further regulatory control, but it also means that the Agency uses none of its regulatory powers to protect the U.S. health and environment from possible future harm.

It is highly likely that if the United States adopts the "Wait-and-See" strategy, the great majority of other producing and using nations will follow suit. Therefore, a domestic strategy of "Wait-and-See" is likely to be equivalent to a world strategy of "Wait-and-See." This approach of inaction would most likely result in continuing large growth in the use of CFCs worldwide.

2. *No-Growth*—The United States limits production to present levels (adjusted for ozone depletion potential) and takes no further action until international conditions and further evaluation of the credibility of the ozone depletion theory warrants.

This strategy is more economically burdensome, but it does signal to other CFC-producing and using nations that the United States is concerned enough about the risks entailed in depletion of the ozone layer that it is willing to take serious action on the basis of present knowledge. At the same time, the strategy makes clear that the United States realizes it cannot solve the problem by unilateral action.

3. *Substantial Emissions Reductions*—The United States reduces its production to some fraction of the level predicted to be necessary on a worldwide basis to achieve an acceptably low level of ozone depletion.

This strategy would result in substantial economic costs, but would demonstrate that EPA believes the problem is serious enough to adopt stringent regulatory actions to protect the United States health and environment from possible future harm. However, it is possible that adoption of this strategy could strengthen the "Wait-and-See" attitude abroad by creating the impression that other nations could afford to wait before taking action.

There are two critical problems which make adopting the "Wait-and-See" strategy unacceptable. First, validation of the ozone depletion theory through environmental monitoring is limited because a minimum ozone change of approximately five percent over a period of ten years would be required before a depletion could be observed with statistical confidence. If such measurements were required before regulatory action and, upon availability of these measurements, the nations of the world immediately reduced production, depletion would still continue to increase substantially (an "overshoot") before falling back slowly to more acceptable levels. This overshoot would be primarily be attributed to the CFCs already in the atmosphere. These two factors combined could result in a peak depletion level where unacceptable biological damage would result if action is delayed until ozone depletion is in fact measured.

Second, while it is true that the pursuit of a "Wait-and-See" strategy has no immediate economic cost attached to it, it would make the attainment of a long-term ozone depletion reduction goal much more difficult and costly when and if regulation is eventually undertaken. If world CFC consumption were allowed to grow uncontrolled through 1990, a 85 percent reduction in 1990 use would be required to achieve the equivalent of a 50 percent reduction from present levels. In addition, failure to limit continued CFC growth in the next decade could lead to large capital investments in CFC-dependent technologies. Such investments represent an undesirable allocation of resources if significant reductions are then required in 1990.

The health and environmental problems resulting from adoption of the "no-growth" strategy are essentially the same as those associated with the "wait-and-see" strategy—overshoot possibly leading to unacceptable biological damage, and the higher cost of subsequent actions. If adequate confirmation of the theory is taken to require *measurable* depletion of the ozone layer, the "no-growth" strategy entails precisely the same risks as the "wait-and-see" strategy, except that confirmation would take longer because of reduced annual emissions in the interim. If a decision to act is instead based on cumulative studies of risk coupled with improvements in the modelling of ozone depletion, a "no-growth" strategy would still result in an unacceptable level of risk—assuming such information requires several years. Furthermore, NAS predicts a "no-growth" strategy would result in a four percent level of depletion within a decade.

Consequently, EPA believes that, given the extreme caution which should be exercised because substantial evidence already indicates that the ozone layer is threatened with depletion, the only acceptable long-term strategy is "substantial emissions reductions."

However, if the "substantial emissions reduction" strategy were implemented immediately, this would likely weaken the United States' effort to produce international action of the same magnitude, and virtually nullify the Agency's domestic actions. By comparison, the "no-growth" strategy, while not providing adequate long-term protection, would put the United States in a more moderate position when it presents its case to other nations.

Therefore, EPA considers it advisable to adopt a "no-growth" strategy in the short-term, limiting United States production to present levels, to convince other nations to agree to concerted international action. EPA would consider following this action with a "significant emissions reduction" policy if international conditions warrant, and if there has been no significant diminution in the present credibility or predictions of the ozone depletion theory.

B. Approaches To Implementing a No-Growth Strategy

EPA has identified two major approaches to achieving a production limitation. The Mandatory Controls Approach would control domestic use of CFCs by regulating final product use or production techniques through product bans and technology-based standards. The Economic Incentives Approach would limit domestic use of CFCs by allocating CFC rights among manufacturers or end users. Each of these two major approaches to control is discussed in greater detail below.

1. Mandatory Controls Approach

One way to limit CFC growth is by banning certain uses or by requiring specific control technologies. While a limit on production would not be achieved directly through this strategy, it could be approximated. This approach would be comparable to other regulatory programs administered by EPA under the Clean Air and Clean Water Acts, where EPA has relied primarily on technological controls. EPA could pursue a similar approach to CFC control either instead of or in addition to a direct production limitation. Three options within this approach are discussed briefly below, along with an outline of their advantages and disadvantages. The options could be used either singly or in combination.

Option I: Technology-Based Control

One option is mandatory control technology standards. These standards would be comparable to EPA Clean Water Act effluent limitations: for each CFC-using production process, EPA would identify and mandate the use of the "best available technology" (BAT) or the "best practicable technology" (BPT). Examples of possible mandatory controls include:

1. Recovery and recycle of CFCs from flexible urethane and rigid non-urethane foam production using carbon adsorption techniques;

2. Performance standards on solvent degreasing equipment;

3. Conversion to CFC–502 (a less effective ozone depletor) in retail food store refrigeration;

4. Use of CFC–22 or helium as a test gas in refrigeration equipment manufacture;

5. Recovery and recycle of CFCs during mobile air conditioning servicing and repair.

Each of these possibilities, as well as others not mentioned above, has varying emissions reduction potential. Furthermore, they are in various stages of technical development, and requiring them would have differential economic impacts depending on firm size and other factors. Through efficient development and enforcement of these and similar standards, it is possible that EPA could meet its desired goal.

The problem with technical standards is that growth in the CFC-using industries could, in a manner analogous to that following the aerosol ban, offset any gains made through the implementation of such standards. The CFC-using industries are sufficiently varied and dynamic so that implications of this problem are not insignificant. The simultaneous implementation of more than one of the mandatory control options may mitigate this problem somewhat.

EPA requests comment on the feasibility and cost of these control options, as well as their applicability to the CFC problem.

Option II: Selective Product Bans

EPA could establish criteria through which to weigh the utility of various CFC-using products against their contribution to stratospheric ozone depletion and ban or restrict those products which were determined to have the least social utility compared to risk. By placing outright bans on certain products or uses of CFCs and mandating periodic review of the remaining uses, EPA might be able to achieve its goal of zero growth in ozone depletion potential.

EPA would employ factors such as the following in deciding which products ought to be subject to a ban:

1. The risk to health, safety and the environment, taking into account the type and quantity of CFC used in the product or process;
2. Availability of another product or process which can make the product or provide a similar service;
3. Relative efficiency and effectiveness of substitutes;
4. Essentiality of CFC use in providing a health, safety, or environmental benefit to the American public;
5. The environmental risk posed by substitutes.

Specific product bans have some of the same disadvantages as technology-based standards. Most importantly, growth in other existing uses and the development of new uses could quickly offset any gains achieved by bans. Also, given the absolute nature of a ban, economic efficiency could be lost, since the prohibited uses may be overcontrolled while other exempted uses incur no controls at all—not even those which would be available at low cost.

The above list of factors is not definitive, but it does illustrate the issues that would have to be addressed in making comparisons of utility. EPA requests comment on the appropriateness of specific product bans to address the CFCs problem, and on the factors used to evaluate specific products.

Option III: Use Ceiling Combined With a SNUR

Under this option, EPA would collect use data from individual users of CFCs. A given percentage of historical use would establish a baseline for each user, and any user wishing to exceed its baseline would be required to file a Significant New Use Rule (SNUR) notice. EPA would evaluate all notices received, and prohibit or limit some fraction of them, such that total use in a given year would not exceed the desired levels. Transfers of use rights from one user to another would also require the filing of a SNUR notice. This would allow EPA direct and continuing control over domestic allocation of CFCs. EPA has the authority to implement a SNUR plan under Section 5 of the Toxic Substances Control Act, if the Agency determines it is in the public interest to act under TSCA rather than under the Clean Air Act.

The disadvantages of using a SNUR in this instance are substantial: first, the Agency would have to obtain massive amounts of data through the use of TSCA Section 8 to establish baselines; and second, the filing and evaluation of SNUR notices would absorb substantial amounts of Agency and industry resources.

2. Economic Incentives Approach

An economic incentives approach would function by directly restricting CFC production, causing prices to increase to ration allowed production. As CFC prices rise, firms must decide whether to continue to use CFCs and pay the higher price, or switch to substitute chemicals or processes to reduce CFC consumption. The firm's decision would be a function of the cost and availability of substitutes, the potential for control and the new increased price of CFCs. Those firms for which control is relatively inexpensive would control more extensively. They would have the incentive to continue increasing control until the cost of an additional "unit" of control was equal to the cost of an additional unit of CFC. Alternatively, firms for which control measures are unavailable or exceedingly expensive would take little or no action to control emissions, choosing instead to incur the higher costs of continued CFC use. If the firms involved are generally profit-maximizers, higher prices would provide them the incentive to search for new control options. It is the different control options available to firms and their desire to minimize costs which gives an economic incentive approach its superior efficiency.

EPA is also investigating a use of a tax or surcharge on CFC use to increase the effective price of CFC use. Although this option is less likely to be employed, the Agency welcomes comment on its relative merit.

A production restriction combined with marketable CFC use rights requires a method by which the initial quota would be distributed. There are several ways in which EPA could distribute CFC production or use rights. One is through direct allocation of production permits, either to manufacturers or to users. The other is through an auction system, under which the transfer or "scarcity" payments would flow to the government. The advantages, drawbacks, and specifics of each method are discussed further below. .

Option IV. Direct Allocation to Manufacturers

EPA would obtain, possibly under the authority of Section 8(a) of the Toxic Substances Control Act (TSCA) of 1976, specific information on the production of CFCs, as well as on the production or purchase of CFC precursor chemicals, from each of the major domestic manufacturers. Using this information, EPA would establish a production ceiling for the industry based on a particular base year or some formula combining several years. This production ceiling would be measured in "permit pounds," a unit which would allow a producer to vary his mix of products among the various CFCs according to the relative depletion potential of each. (This concept is described in Section II.B.2.a.) Sales of allocations among the manufacturers, or to potential new entrants into the industry, would be permitted.

As described above, the imposition of a production ceiling on CFC manufacturers would induce them to raise the price charged for CFC to allocate the reduced quantity of CFC among users. This increased cost would create an incentive for users to develop CFC conservation techniques or to switch to substitutes. EPA anticipates that such price increases and the resulting profits to manufacturers would be small initially since the anticipated shortfall in production created by the ceiling would not be large. If the production ceiling were to continue for several years, however, the transfer payments accruing to manufacturers could become quite large. The RAND Corporation estimates that total transfer payments will eventually exceed $2 billion. EPA would consider methods which minimize the windfall to manufacturers and minimize impacts on users.

Option V. Direct Allocation of CFC Permits to Users

Instead of allocating permits to manufacturers as outlined above, EPA could make a direct allocation of CFC permits to user industries. This allocation could be made according to historical use, capacity, or some other measure. While insufficient information on the number and size of firms in user industries would make an equitable allocation extremely difficult to implement, this method of allocation might be the most effective in reducing the volume of explicit transfer payments either to manufacturers or to the government. EPA recognizes that, depending on the market structure and the dynamic interrelationship among using and producing industries, a substantial portion of the transfer payments might ultimately accrue to manufacturers even under a system of allocating permits to users. EPA specifically requests comment on this issue.

Option VI. Government Auction of Permits

Rather than issuing permits *gratis*—and thereby creating the possibility that manufacturers would capture the full volume of transfer payments—an alternative would be for EPA to sell permits to the manufacturers in an auction. This method would allow the government to recoup a large portion of the transfer payments from the manufacturers. This option would be administratively simple, and would be less likely than Option I to freeze the market shares of the manufacturers. Also, a new entrant to the CFC-producing industry would be able to enter the market for permits without the additional cost disadvantage he would encounter if permits were allocated to existing manufacturers rather than auctioned.

Another alternative would be to auction permits to CFC users (those firms which use CFCs in their production processes or as end products). This option would effectively eliminate the producer's share of the transfer payments. In addition, it would maintain the present level of competition among manufacturers, would be administratively simple, and would not significantly deter competition, entry, or exit for either manufacturers or users.

To make matters even simpler administratively, EPA could auction permits in an unrestricted market to manufacturers, users and other potential participants. Users would buy what they could afford to meet their needs. Manufacturers would buy permits to capture some portion of the market, and perhaps to supply CFCs to those users too small to enter the auction or the permit aftermarket. This type of auction would be the easiest to conduct, since monitoring of participation would not be required.

EPA solicits comments on the efficiency and efficacy of the three major incentives-oriented approaches to CFC control outlined above, and especially, comments on possible methods of direct allocation to users or manufacturers; methods of auctioning permit rights; and the impact and incidence of transfer payments.

2.a. The Permit Pound Concept

EPA recognizes that different CFC compounds present varying potential for depletion of stratospheric ozone. Indeed, EPA would structure the production ceiling regulation in such a way as to provide incentives for industry users to shift from those CFCs most harmful to the stratosphere toward those CFCs posing a lesser threat.

EPA would provide this incentive by establishing the production ceiling in terms of "permit pounds". Under this strategy, each type of CFC would be weighted according to its ozone depletion potential relative to the other CFCs. Ozone depletion potential is primarily a function of molecular chlorine content by weight and the lifetime in the atmosphere of the various CFC compounds. Research to date results in the permit pound conversion factors shown in Table 4.

Table 4 compares the ozone depletion potential of other CFCs with that of CFC-11. For example, according to the chlorine content criteria, CFC-115 is only 20% as harmful to the ozone layer as an equivalent weight of CFC-11.

Table 4.—*Depletion Potential Factor*

Type of CFC	(CFC-11 = 1)
CFC-11	1.00
CFC-12	.79
CFC-113	[illegible]
CFC-114	.40
CFC-115	.20
CFC-22	[1] .18

[1] CFC-22 cannot be correctly measured strictly according to chlorine content. CFC-22 is partially halogenated, which means that relatively little of the emitted compound ultimately reaches the stratosphere, because of its shorter lifetime.

Source: Lawrence Livermore Laboratory.

2.b. Establishing a Production Ceiling

In setting a production ceiling, EPA would use the permit pound concept in the following manner: production of each CFC in the base year would be multiplied by its respective depletion factor, and the resulting products would be added to yield the allowable ceiling on ozone depletion potential. Under an economic incentives approach, ozone depletion would remain constant, although the use of permit pounds would allow actual poundage to vary. The substitution of less-depleting CFCs allows the overall production level of CFCs to increase without adding to the ozone depletion potential. (See Table 5 and discussion following.)

Table 5.—*Ozone Depletion Equivalents of a Hypothetical Base Year Production*

Type of CFC	Hypothetical base year production (millions of lbs.)	Ozone depletion factor	Ozone depletion equivalent (millions of lbs.)
CFC-11	100	1.00	100
CFC-12	100	.79	79
CFC-113	100	.77	77
CFC-114	100	.40	40
CFC-115	100	.20	20
CFC-22	100	.18	18
Total	600		343

Applying the ozone depletion factors to a hypothetical total base year production of 600 million pounds distributed equally among the major CFCs yields an ozone depletion equivalent of 343 million pounds. This may be considered an "allowable stratospheric chlorine ceiling." Such a ceiling holds potential CFC damage to the stratosphere constant while allowing individual firms to alter their production of individual CFCs within the bounds of the ceiling.

EPA would issue production permits under any of the three options outlined above. Compliance monitoring would consist of a comparison of manufacturers' CFC production records with the amounts of permits that they (a) were allocated under Option I, plus those purchased from other manufacturers; (b) received in production orders from users, under Option II or III; or (c) directly bought in auction, under Option III, plus purchases from others.

Permits, whether auctioned or allocated directly to users or manufacturers, would be in permit pound units. In the example given above, this allocation is stated in CFC-11 equivalent units. For purposes of determining production mix, firms would be allowed to produce relatively more of those CFCs which have less ozone depletion potential compared with the base compound. The multiplier determining the allowable production equivalent per permit pound is equal to the *inverse* of the ozone depletion factor for each CFC. In short, the less depleting a given CFC, the more would be allowed to be produced per permit pound. For example, the ozone depletion factor for CFC-12 is 0.79 and its inverse is 1.28. Therefore, for each permit pound it is allowed under the production ceiling, a firm could produce 1.28 pounds of CFC-12 compared with only 1.00 pound of CFC-11. The production equivalents derived from Table 4 are shown in Table 6.

Table 6.—*Derivation of Production Equivalents*

Type of CFC	Ozone depletion factor	Production equivalent
CFC-11	1.00	1.00
CFC-12	.79	1.28
CFC-113	.77	1.30
CFC-114	.49	2.04
CFC-115	.20	5.00
CFC-22	.18	5.56

EPA anticipates that the permit pound concept would provide a strong incentive for CFC manufacturers and users, where technically feasible, to seek ways in which to shift their products and processes toward those CFCs with less ozone depletion potential.

EPA requests comments on the permit pound concept, its implementation, and the methods to be used to determine the production ceiling and the production equivalent multipliers.

2. c. Exports Under the Production Ceiling

The global nature of the risks from CFC emission bears heavily on the question of how to treat United States' exports under any regulatory action being considered by EPA. As discussed in Section I.E. above, CFC emissions anywhere around the world contribute equally (depending on the type of CFC and the volume of emissions) to the potential for ozone depletion, which in turn affects all areas of the globe.

Under a production ceiling, EPA's current thinking is that firms could continue to export CFCs in bulk form or in nonaerosol articles, provided that the additional amount would not exceed their quota under the production ceiling. However, it appears unlikely that firms would continue exporting because they would be placed in an unfavorable pricing position in the foreign CFC market. In uses where large amounts of CFCs are contained in the article, such as centrifugal chiller, exporters would probably alter the present practice of shipping the article overseas fully charged with CFCs. Manufacturers might find it advantageous to ship units charged with a test gas, which is then exchanged for the CFC overseas. Such action, however, would depend on the quantity of CFCs contained in the article and the degree to which the increased cost of domestically purchased CFCs could be passed through to the overseas importers.

Under this approach of including exports in the production ceiling, foreign firms could conceivably increase their production to offset any decrease in United States' exports, which would run counter to the long term goal of reducing global CFC emissions. However, some nations have already taken action to limit their capacity to produce CFCs and have indicated that they will consider taking additional actions. EPA, in cooperation with the Department of State and other concerned agencies, will continue to encourage other countries to reduce global releases of CFCs. Furthermore, the alternative, of excluding exports from the production cap and granting exporters additional permits equal to their present level of exports, might have serious international ramifications. The global problem may be exacerbated if the United States is in the position of encouraging other nations to take further actions to control CFC emissions while at the same time not controlling United States' CFC exports.

A theoretical third alternative would be to selectively exclude certain use categories of exports from the production cap and include others, but this would appear to be incompatible with the general philosophy of an economic incentives approach; would be difficult to defend on a use category basis (especially since the desirability of receiving CFCs for certain uses or in certain products would vary among countries); would not solve the problem of bulk shipments of CFCs for unknown uses; and would be difficult to administer.

EPA requests comments on these three alternative approaches to export control, considering business and economic effects, effects on global CFC emissions, international ramifications, and ease of administration. EPA also requests comments on the applicability of Section 12(a)(2) of TSCA to the question of CFC exports. This section empowers the Administrator to control exports if he finds that they would present an unreasonable risk of injury to health or the environment in the United States. Releases from CFCs produced for export will have the same affect on the health and environment of the United States as chemicals produced for domestic use.

2.d. Imports of CFC and CFC-Containing Articles

CFCs are presently imported both in bulk form and in articles. For the production ceiling regulation to be fully efficient, a mechanism must be devised to regulate imports of CFCs and CFC-containing articles so that imports are neither given an advantage nor placed at a disadvantage in comparison to domestic manufacturers. Mechanisms to control imports of these items include: 1. Freezing imports at current levels;

2. Establishing a permit system for imports;

3. Accounting for imports in establishing the production ceiling and including importers in the established allocation system.

The first alternative would operate like a quota system with the allotment equal to the amount of bulk CFCs or CFC-containing articles imported in the base period. CFC imports would be tied to the level of imports for a previous year with both the mix of CFCs and the articles containing CFCs remaining unchanged. This alternative would favor existing importers and virtually prohibit new entrants to the import market. It also would enable importers to enjoy some small profit advantage since they would not be operating under a production ceiling similar to that under which domestic manufacturers of CFCs would be operating. Domestic manufacturers and retailers are not expected to be significantly penalized by this alternative since domestic demand is expected to exceed the supply of CFCs from all sources.

The second alternative would be implemented by establishing a separate ceiling for importers and requiring them to purchase permits equal to the amount of pounds of CFCs they want to import either in bulk form or in articles. Their permit price would likely reflect the domestic permit price. This alternative would remove the possibility of an unfair competitive advantage accruing to foreign manufacturers due to domestic CFC regulation. It would also permit the sale of permits between firms importing to the United States. Under this alternative, current importers of CFCs should not have any advantage over those attempting to enter the import market. Furthermore, importing firms would be permitted the same flexibility in CFC use and product mix allowed to domestic firms.

The third alternative could be implemented by including imports under the domestic production ceiling and allowing importers to compete in the permit market along with domestic firms. Like the second alternative, this option would allow the transfer of CFC permits and also would remove the possibility of importers enjoying a cost advantage over domestic manufacturers. It would also allow flexibility in the mix of CFCs originating domestically and abroad, since these two groups would be competing in the same permit market. EPA solicits comments on these options for controlling imports and exports under the proposed production cap.

2.e. Anticipated Technical Responses to an Economic Incentives Approach to a Production Ceiling

EPA has undertaken research to attempt to predict the measures that CFC-consuming industries might take to stay within the production ceiling. The RAND Corporation has identified a number of steps that industry may take to reduce CFC consumption. These steps do not necessarily exhaust the options for recovery and recycle or substitutions that may be available in the future. Indeed, EPA expects that additional options will become available to industry as research and innovative techniques are stimulated by higher CFC prices.

Initial Actions

a. Large molded foam plants would install recycle and recovery systems;

b. CFC-12 would be replaced by CFC-502 in the manufacture, installation, and servicing of medium temperature refrigeration systems, and by CFC-22 in leak testing in the servicing of retail food refrigeration systems;

c. Solvent cleaning and drying units would either conserve through recycling or find substitutes, and some units would by modified to reduce losses;

d. Flexible slabstock foam plants would convert to methylene chloride.

Intermediate Actions

a. Polystyrene sheet plants would install recycle and recovery systems;

b. All solvent cleaning and drying units would further substitute other solvents, and medium-sized units would also recycle more intensively;

c. Molded foam plants and flexible slabstock plants would install recycle and recovery systems where CFC-11 was still used.

Later Actions

a. All flexible foam plants would improve their collection efficiencies;

b. Polystyrene sheet plants would convert to pentane blowing agent;

c. All solvent cleaning and drying units would further substitute other solvents, and large units would increase their recycling efforts.

These three sets of actions are anticipated to produce the following reductions (from projected levels) in CFC use from 1981 to 1983. (Reductions are given in both real and permit pounds).

Table 8.—Reductions From Uncontrolled Growth

[In millions of pounds]

Phase	1981		1982		1983	
	Real pounds	Permit pounds	Real pounds	Permit pounds	Real pounds	Permit pounds
Initial action:						
a	13.2	13.2	13.9	13.9	14.5	14.5
b	0.0	3.6	0.0	3.8	0.0	4.0
c	20.7	15.9	21.3	16.4	22.0	16.9
d	15.0	15.0	15.8	15.8	16.5	16.5
Total	48.9	47.7	51.0	49.9	53.0	51.9
Intermediate action:						
a	7.6	6.0	8.0	6.4	8.4	6.7
b	4.9	3.8	5.2	4.0	5.6	4.3
c	6.0	5.2	6.3	5.4	6.6	5.7
Total	18.5	15.0	19.5	15.8	20.6	16.7
Later action:						
a	6.5	6.5	6.8	6.8	7.2	7.2
b	7.6	6.0	6.0	6.4	8.4	6.7
c	13.6	10.5	14.8	11.2	15.5	11.9
Total	27.4	23.0	27.4	24.4	31.1	25.8
Grand total	90.0	81.8	95.1	90.4	100.3	91.1

NOTE.—Figures may not sum due to rounding.

Source: Rand Corporation.

III. A Summary of Issues on Which Comments Are Requested

EPA welcomes general comment on all aspects of chlorofluorocarbon regulations, from members of industry and the general public. EPA especially solicits comment on the following issues:

1. Scientific validity of the ozone depletion theory. Comments on the two 1979 reports of the National Academy of Sciences, and the NASA Report 1049, December 1979.

2. Risks of continued world chloroflurocarbon emissions. Comments on how these risks, both to human health and the environment, should be quantified and evaluated.

3. Strategies for level of CFC control. Comments on the validity of a Production Ceiling Strategy, as contrasted with Wait-and-See, and Substantial Emissions Reduction.

4. International aspects of CFC regulatory effort. Comments on how to inprove the level of international cooperation on this issue and issues related to the import and export of CFCs.

5. Approaches to achieving a production ceiling domestically: comments on economic incentives approaches to chemical regulation; desirability of the avarious auction and allocation methods; the permit pound concept; and methods of directly allocating quotas or permits to manufacturers or to users. Comments also on the mandatory controls approach to CFC regulation, including production bans, technology based standards, and SNURs.

Douglas Costle,

Administrator.

September 30, 1980.

References

1. 43 *Federal Register* 11332.

2. RAND Corporation. *Economic Implications of Regulating*

Chlorofluorocarbon Emissions from Nonpropellant Applications, (Santa Monica, CA, June 1980).

3. Department of Transportation, *Upper Atmospheric Programs Bulletin*, No. 79-5 (October 1979, Washington, DC).

4. National Academy of Sciences, *Halocarbons: Effects on Stratospheric Ozone*, (September 1976, Washington, D.C.).

5. NAS, *Stratospheric Ozone Depletion by Halocarbons: Chemistry and Transport*, (November 1979, Washington, D.C.)

6. NAS, *Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons*, (December 1979, Washington, D.C.)

7. National Aeronautics and Space Administration, RP-1049 (December, 1979, Washington, D.C.), *"The Stratosphere: Present and Future"*.

8. National Cancer Institute, *Incidence of Nonmelanoma Skin Cancer in the United States, 1977-78*, April, 1980.

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STATEMENT OF
THE
NATIONAL AUTOMOBILE DEALERS ASSOCIATION

The National Automobile Dealers Association (NADA) is a trade association representing over 20,000 franchised new car and truck dealers across the country. NADA members are engaged in retail sale of both new and used motor vehicles, including passenger cars, trucks, vans, and Jeep-type vehicles. In addition to retail sales of motor vehicles, NADA members are engaged in the repair and service of vehicles. Furthermore, NADA members are involved with the retail sale and service of both factory and dealer installed mobile air conditioning units.

Inasmuch as a major non-aerosol use of chlorofluorocarbons (CFCs) include the use of CFCs as a refrigerant in mobile air conditioning units and as the blowing agent for open-cell flexible foams used in automobile seat cushions, NADA welcomes the opportunity to comment to the United States Senate Committee on Environment and Public Works, Subcommittee on Toxic Substances and Environmental Oversight, on the appropriateness of restricting the use of chlorofluorocarbons (CFCs).

Introduction

CFCs are stable, non-flammable and relatively non-toxic synthetic chemical compounds in the halogenated hydrocarbon family. Major non-aerosol uses of CFCs include its use as a refrigerant in mobile air conditioning (MAC) units and as the blowing agent for open-cell flexible foams used in manufacturing automobile seat cushions. MAC units are currently one of the largest CFC-using product areas, and the major members of the MAC industry are the automobile manufacturers.1/

The MAC industry in the United States is large and well established. In 1980, nearly 77 percent of the passenger vehicles sold were equipped with MAC units.2/ The essentiality of automotive air conditioning in contributing to the improved health and safety of automobile drivers is seen in its key role of reducing the debilitating effects of heat stress on human activity.

Driving under the heat stress conditions commonly experienced in many parts of the United States during the summer months has been shown to adversely affect driver alertness.3/ A study of the effect of heat stress in driving performance conducted for the National Highway Traffic Safety Administration has concluded that suitable air conditioning equipment or other

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1/ CFC-12 is the refrigerant used in virtually all MAC units, such as in automobiles, trucks, and farm vehicles.

2/ Ward's Automotive Yearbook, 1981, p. 102.

3/ Lack of alertness has been ascribed as a key factor in many of the fatalities and disabling injuries experienced annually in traffic accidents in the United States. "Mobile Air Conditioning," White Paper: Chlorofluorocarbon/Ozone Depletion Issue, p. 1, report by DuPont de Nemours and Co. (Inc.), Wilmington, Delaware, August, 1979.

effective countermeasures should be available to drivers who will be exposed for extended periods of time to heat stress conditions.[4] CFC air conditioning refrigerants are thus an important asset in current programs to increase passenger safety in transportation.

In light of the above, and for the reasons set forth below, NADA submits that the proposal by the Environmental Protection Agency[5] (EPA) for restricting the production of CFCs should be withdrawn.

I. There is insufficient scientific evidence to support the hypothesis upon which EPA relies to regulate CFC use.

NADA submits that no regulation of CFC use is appropriate at this time because the ozone depletion hypothesis upon which EPA's regulatory initiative is premised remains unverified. EPA has by its own admission acknowledged that "the scientific models on which the theory is based have not been conclusively validated."[6] The basis for the regulation is thus a sequence of possible events, yet to be verified, and an unverified theory that the release of CFCs into the atmosphere may eventually deplete the earth's ozone layer.

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[4] Id. at 2.

[5] Published as an Advanced Notice of Proposed Rulemaking (ANPR) on October 7, 1980 (45 FR 66726).

[6] Page 2 of a letter from Steven D. Jellinek, Assistant Administrator for Pesticides and Toxic Substances for the EPA, to Herbert T. Gilkey, Deputy Director of Public Affairs, Regulation, Air Conditioning and Refrigeration Institute.

Predictions that CFCs deplete stratospheric ozone layers are based on computer models, rather than actual measurements of ozone atmospheric chemistry, and numerous discrepancies remain between what the computers assume and what actual measurements have shown.[7/] Models currently "calculate" that 1.8 percent depletion due to CFC releases should have occurred by 1979.[8/] Analyses of ozone measurements made to date, however, have shown no evidence of depletion or of abnormal global trends.[9/]

The discrepancies between the theory predictions and actual atmospheric measurements are so great that NADA opposes at this time any further regulation of CFCs. The EPA banned the use of CFC as an aerosol propellant on the basis of an unverified theory, and now appears to be moving to regulate essential non-aerosol uses of CFCs in the same manner. NADA contends that the decision to initiate additional regulation

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[7/] This problem may be due to the fact that the estimates are derived from many assumed parameter values that are very uncertain. For example, a sensitivity analysis performed by International Research and Technology Corporation suggest the total CFC emissions figure for 1976 could be as low as 46.7 million pounds or as high as 217.6 million pounds. Economic Implications of Regulating Chlorofluorocarbon Emissions from Nonaerosol Applications, R-2524-EPA, p. 131, June, 1980. Prepared for the EPA by the Rand Corporation.

[8/] DuPont White Paper, Position Paper, supra note 4, at 30.

[9/] The results are from ground level monitoring stations worldwide and, since 1970, by satellite. Id. at 29.

of CFCs without conclusive experimental proof of the ozone depletion theory, and in the absence of scientific agreement on such a theory, presents an important question regarding the agency's authority.

NADA contends that the EPA should defer consideration of CFC regulations until completion of industry and government programs that are expected to clarify uncertainties in the ozone depletion theory. Most of the world's scientific community agree that there is no unreasonable risk to health and environment in awaiting verification of the extent and impact, if any, of ozone depletion.[10] Scientific knowledge regarding CFCs and the ozone layer is rapidly evolving and, while such validation is not now technically feasible,[11] new measurements and scientific developments provide the basis for great optimism that more will soon be known about this controversial subject.

NADA submits that the current uncertain status of the ozone depletion theory does not justify initiating expensive, costly, and disruptive regulatory proceedings when there is no risk in waiting to determine its validity. The issues raised concerning the role of CFCs are complex and subject to many uncertainties. The ozone depletion theory cannot be properly addressed without an adequate opportunity to assemble scientific information which is currently unavailable. Without such information, it is impossible for NADA to justify the proposed production restriction on CFCs.

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[10] A study group of the Royal Society (the British equivalent to the United States National Academy of Science) reported that "there is no need for hasty action." "Pollution in the Atmosphere," The Royal Society Study Group Report, p. 13, June, 1978.

[11] The EPA has stated that the ozone depletion theory has not yet been observationally validated and that such validation will not be technically feasible until mid-decade. *Supra* note 7.

II. Ozone depletion is an international problem which cannot be unilaterally solved by the United States.

The production of CFCs is an international concern which requires assessment and resolution by all of the industrialized nations of the world. The curtailment of the use of CFCs in the United States would represent only a small percentage of world-wide emissions and would have a marginal, if any, impact. No single nation accounts for a large enough portion of world CFC use or production to be able to unilaterally control ozone depletion.[12/] CFCs emissions around the world contribute equally to ozone depletion, and any damage caused by CFCs emissions will not be limited within the boundaries of the source country.

[12/] The EPA has recognized that ozone depletion is a truly international concern, and further, that unilateral United States' actions against CFCs would be fruitless. Id.

NADA submits that the United States has already set a worldwide example by banning the use of CFCs in aerosols, in spite of the fact that other countries continue to use CFCs in aerosol production. It thus makes little sense for the United States to contemplate restricting critical non-aerosol uses of CFCs in the face of such findings.[13/] Regulation of non-aerosol applications of CFCs in the United States would be of little value, and would reduce worldwide emissions by only a small fraction, if at all. As past experience has shown, any reductions or limitations would be negated by increased production in other parts of the world.

If the United States were to pursue a regulatory program while the rest of the world did not, the continued unregulated emissions abroad would limit the effects of the EPA proposal to a modest worldwide effect, with a hopelessly unfavorable balance between the costs and benefits to the United States.[14/] NADA submits that global CFC levels would, therefore,

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[13/] A recent study has concluded that an international ban of CFCs remains unlikely: "Most likely, the U.S. will be in the position of trying to negotiate an international treaty (or its equivalent) regulating CFC emissions, comparable to the treaty prohibiting atmospheric testing of nuclear weapons. The analysis of benefits and costs, which shows a close balance . . . or a net benefit of continued emissions, and the uncertainty analysis just provided, falls short of providing a conclusive case to present to other governments in support of such a treaty or agreement." Bailey, Uncertainties and Benefit-Cost Analysis of CFC Control, p. 77, University of Maryland, Department of Economics, August, 1980.

[14/] *Id.* at 3.

be affected minimally or not at all. There remains the need for international cooperation rather than further unilateral action by the United States if any such proposed regulation is to have a chance to be effective.

III. There are no practical alternatives to CFC refrigerants.

CFCs are considered highly desirable from a worker and consumer safety standpoint because they are stable, nontoxic, and nonflammable. There are no satisfactory alternatives meeting the necessary criteria of safety, energy efficiency, performance, and value in use; alternative substitutes appear to be toxic or flammable and unsatisfactory from both a health and economic perspective. NADA submits that EPA is focusing only on the possible risks of CFCs and is ignoring the above important benefits.

If the proposed regulations to limit the production of CFCs were adopted at this time, with no alternative refrigerants readily available, the growth of the refrigeration and air conditioning industries in this country would grind to a halt. To curtail the use of CFCs in such equipment is to curtail the use of such equipment itself. Such a situation would lead to the expensive process of retooling the current machinery and equipment for an alternative that either does not exist or has been shown to be more costly and less efficient.

If an alternative to CFCs is required in automotive air conditioning systems and seat foam manufacturing processes, General Motors would have to invest close to $1 billion for developing such alternative systems.[15/] General Motors estimates that, if an alternative refrigerant were selected now, it would take five to seven years to test, develop, and place into production a system that would be compatible with the new refrigerant; additionally, if General Motors were to change to an alternate blowing agent used in flexibile seat foams, the development time to place such a foam into production is currently estimated at between two to three years.[16/] NADA submits that, until a reasonable and feasible alternative exists, the cost of retooling are prohibitive and render the EPA proposal unconscionable.

The energy conservation advantages of CFCs, historically overshadowed by the better known advantages of engineering, processing, and safety, are gaining recognition as an essential factor in the importance of continued CFC use.

[15/] White Paper: Recommended Actions to Improve Cost/Effectiveness of Government Regulations, Section II, report by General Motors, June 9, 1980.

[16/] Id. Another example of the long lead time required for retooling when components are redesigned was given by Delco Air Conditioning, a division of General Motors. Delco has designed a small and light compressor which they have been phasing steadily into service; but they estimate that it will require approximately ten years for the compressor phase-out of their older unit. Supra note 8, at 134.

Conversely, NADA contends that a ban or restriction on the use of CFCs would thus be considered as both an energy and economic penalty. The proposed ban would cause additional and serious aggravation of our current energy problems and be contrary to our Nation's economic and environmental policies.

The Battelle/Columbus Laboratories released a study concerning the problems of increased energy consumption and concluded that there is a significant energy penalty associated with a ban on CFCs. The results indicated that an outright ban in 1980 on the use of CFCs would have the cost equivalent of a net energy penalty of 9.5 billion gallons of fuel in the tenth year of the ban and a cumulative total of 49.8 billion gallons of fuel for the first decade following the ban.[17/] The energy penalties would result from using the "next best alternative" to CFCs which, for MAC units, has been shown to be the unsatisfactory substitutes of ammonia[18/]

[17/] Energy Consequences of Chlorofluorocarbon Regulation, p. 2. a report by Battelle/Columbus Laboratories. To put such figures in perspective, it should be noted that the 9 billion gallons of fuel calculated for the tenth year of a ban on CFCs is equivalent to the amount of fuel required to drive 12 million average cars (about 10 percent of all U. S. cars) for one year. Id. at 6.

[18/] The study also noted the problems of ammonia's toxicity and flammability. Id. at 13.

and CFC-22.[19] NADA submits that, as the above study indicated, the continued use of CFCs would result in large energy savings to our Nation, and any conversion to an alternative refrigerant at this time would penalize the Nation's diminishing energy supplies.

IV. Regulation of CFC use would have substantial adverse economic effects.

The major members of the MAC industry are the automobile manufacturers, and NADA submits that a reduction in the availability of CFC refrigerants would have an adverse economic impact upon this industry. The MAC industry is a major employer,[20] and the annual sales of original equipment alone exceed seven million units at a cost of over $2 billion.[21] On a larger scale, the importance of CFCs to the economy can be seen from the following statistics contained in a 1979 study on the ozone depletion issue.[22]

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[19] CFC-22 has been considered as an alternative refrigerant for use in automobile air conditioning primarily because it is mainly removed naturally in the lower atmosphere; however, it necessitates higher equipment operating pressures to achieve proper operation. To obtain these higher pressures, stronger and heavier equipment than what is currently used is needed for safety reasons. Since automobile manufacturers have identified weight reduction as an important means to help achieve mandated energy conservation goals by 1985, such weight increases to accommodate CFC-22 would result in increases in fuel waste. *Supra* note 4, at 2-3.

[20] The factories that produce compressors, condensors, evaporators, and accumulators have sizable employment. General Motors alone employs about 13,200 workers in the production of MAC components. *Supra* note 8, at 113.

[21] *Id.*

[22] *Supra* note 4, at 16-17.

(1) Approximately $375 million worth of CFCs are sold annually.

(2) More than 650,000 jobs in the United States are related to CFC use.

(3) Approximately 240,000 domestic business locations are involved with the use of CFCs.

(4) Annual value of goods and services in the United States which depend to some extent upon CFCs exceed $17 billion.

(5) Value of installed products in the United States which use CFCs is greater than $90 billion.

NADA contends that a regulation banning production of CFCs would thus have the effect of an economic sanction against the industrial base of the United States at a time when many vital sections of the economy, such as the steel and automobile industries, are experiencing both short-term and long-term decline in sales and employment.

The EPA's proposed institutional trading and permit structure for the use of CFCs also has the potential for dramatic market fluctuations that would drive up the price of CFCs to both users and consumers and adversely impact many small businesses. NADA submits that, as many of its dealer members are small businesses from the standpoint of CFC use, adverse economic and social consequences of any further regulation must be fully understood before such a proposal may be deemed appropriate. This is especially important at a time when depressed sales, coupled with unreasonably high interest rates, have led to a startling decline in the number of franchised dealerships to the lowest total since the infant days of the automotive industry.[23/]

EPA is charged under both the Clean Air Act, 42 U.S.C. Sections 7457, 7617 and the Toxic Substances Control Act, 15 U.S.C. Section 2605, with the task of carefully assessing the economic consequences of any regulation which may reasonably be anticipated to affect ozone in the stratosphere. They are also required under each statute to take into account the impact of any proposed regulation upon small businesses. Further, the newly enacted Regulatory Flexibility Act (RFA), Pub. L. 96-354, directs the EPA to view small businesses involved with the regulatory process in light of their unique circumstances.[24/]

[23/] Automotive News, November 10, 1980, p. 42. The domestic dealership total declined by 1,643 in model year 1980, the worst downturn in 22 years. Calendar year 1980 registered a loss of 1,607 dealerships which appears even more disastrous when compared with a loss of only 96 dealerships in calendar year 1978. Automotive News, February 23, 1981, p. 1. The news continues to be discouraging as first quarter 1981 domestic dealership closings totaled 221, the second highest first quarter decline in the 20 years that Automotive News has been compiling census data on a quarterly basis. Automotive News, May 4, 1981, p. 1.

[24/] The enunciated purpose of the RFA, effective January 1, 1981, is to encourage adjustment of regulatory and informational requirements to the scale of the regulated entity, e.g., to minimize regulatory impact on small business and other small entities.

The impact on small businesses of a proposed restriction of the use of CFCs should thus be determined before pursuing any regulatory scheme.

Conclusion

For the reasons set forth above, NADA submits that the proposed regulation restricting the production of CFCs should be withdrawn. The intention to limit the production of CFCs is based on an unverified theory which has not been accepted by the majority of the nations of the world. It also fails to take into account the severe hardships it would place upon the American public and small businesses which are dependent upon continued CFC availability. Any regulatory action at this time, without further economic technological assessment, would lead to hardships for automobile dealers; it would also lead to more costly and less satisfactory products for the consumer, adverse impacts on our Nation's energy supply, and the creation of hazards more significant and real than the theoretical problem such regulation seeks to avoid.

NADA welcomes the opportunity to comment on this matter.

NATIONAL AUTOMOBILE DEALERS
ASSOCIATION

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July 31, 1981

Honorable Slade Gorton
Chairman
Subcommittee on Toxic Substances
& Environmental Oversight
3327 Dirksen Senate Office Bldg.
Washington, D.C. 20510

Dear Chairman Gorton:

Otisca Industries, Ltd., requests that this letter be included in the permanent record of hearings held before the Subcommittee on Toxic Substances and Environmental Oversight on Thursday, July 23, 1981, regarding the environmental impact of chlorofluorocarbons.

STATEMENT OF OTISCA INDUSTRIES, LTD.

Because the United States has 31 percent of the world's economically recoverable coal reserves, coal development is increasingly seen as a means of reducing our nation's dependence on foreign oil and gas. The Powerplant and Industrial Fuel Use Act of 1978, for example, articulates a Congressional policy "to encourage and foster" the greater use of coal as a primary energy source in lieu of natural gas and petroleum. 1/ The Act also states, however, that our nation's air quality goals are not to be sacrificed to meet this objective. 2/ In fact, there is considerable concern that greater reliance on coal may result in additional atmospheric pollution unless appropriate preventative steps are taken. Otisca Industries, Ltd., a New York-based company employing 31 persons, has developed pollution control systems enabling the nation to resolve these competing concerns. In doing so, however, Otisca finds itself in a dilemma of its own.

The Otisca Process constitutes one of the most efficient methods for cleaning sulfur and fly ash from coal. In a closed

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1/ 42 U.S.C. § 8301.

2/ 42 U.S.C. § 8471.

system, chlorofluorocarbons (CFCs) are used to separate the hydrocarbon content of coal from its impurities before the coal is burned. Despite the fact that Otisca has demonstrated the capacity to eliminate known pollutants using CFCs, the Environmental Protection Agency in an Advance Notice of Proposed Rulemaking has stated its intention of curtailing further use of all CFC applications, regardless of their utility, because it "suspects" that such compounds may deplete stratospheric ozone. 3/ Despite years of speculation, the ozone depletion theory remains just that--a theory. It has never been validated. Nevertheless, on the basis of questionable scientific evidence, EPA appears to be ready to wipe out a process which has been designed to further one of the principal goals of this Committee--cleaner air.

As will be shown below, Otisca will be forced to liquidate if EPA denies us CFCs. Of equally great concern, the continuing uncertainty over what course of action EPA will ultimately take with respect to CFCs has made it most difficult for us to persuade those interested in our systems to purchase them. Otisca questions whether it is an appropriate exercise of federal power to ban the use of a widely used chemical solely on the basis of unsubstantiated theories regarding its possible impact on the environment.

In view of the important commercial applications of CFCs, including applications that are helping utilities achieve the purposes of Title I of the Clean Air Act, we submit that a more reasonable approach to this issue is the one embodied in S. 517, the Ozone Depletion Validation Act of 1981, introduced by Senator Bentsen. Because that measure would bar EPA from curtailing the use of CFCs without first establishing the validity of theories regarding their environmental impact, it would prevent the agency from arbitrarily destroying businesses such as Otisca that must rely heavily on CFCs for the products and services which they market.

The Importance of Clean Coal

Reducing sulfur dioxide and particulate emissions of coal-fired power plants has long been one of the cornerstones of our nation's environmental policy. For example, the Environmental Protection Agency in June 1979 issued New Source Performance Standards requiring the continuous removal of up to 90 percent of the potential combustion concentration of SO_2 from boiler flue gases of power plants constructed since September 18, 1978. Except for some of the very low sulfur coals and lignites, however, practically no U.S. coals can meet these standards without some form of pre-combustion or post-combustion sulfur control. At the same time, domestic coal consumption is expected

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3/ 45 Fed. Reg. 66726 *et seq.*, October 7, 1980.

to increase from the 620 million tons burned in 1977 to 1144 million tons by 1990, and by even greater amounts in other countries. 4/ Because this sharply increased use of coal may lead to greater generation of air pollutants, it is likely that there will be strong demands for improved coal cleaning technologies. In fact, the Congressional Research Service reports that the plentiful supply of high-sulfur coals such as those found in the U.S. Eastern Interior Basin will be competitive in foreign markets only if ways can be found to clean it before shipping. 5/

Laying aside the environmental problems, it has long been assumed that the burning of "dirty" coal adversely affects the boilers of coal burning plants. A study of five TVA plants by the Department of Energy recently confirmed these assumptions, finding a direct correlation between coal quality and boiler maintenance to the extent that each percentage reduction in the ash and/or sulfur content proportionately reduced boiler maintenance costs. 6/ The study provides a clear example of the costs incurred when pollutants are not removed from coal.

The Otisca Process

Formed in 1972 and presently employing 31 people, Otisca is principally involved in developing, constructing and servicing systems for removing known pollutants from coal. The company holds several patents, collectively called the Otisca Process, which rely on CFCs contained in closed systems to recover hydrocarbon values from and increase the BTU potential of raw coal. Under contract with a major Midwest utility, Otisca has virtually completed a 125 ton per hour plant for processing coal at one of its electrical power generating facilities. Otisca processed coal is also being used as a fuel in GM's new coal-powered Cadillac El Dorado. 7/

Beneficiation, or physical coal cleaning, is a "proven and cost-effective technology for removing pyritic sulfur and ash-

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4/ The Energy Factbook, Committee on Interstate & Foreign Commerce, United States House of Representatives, 96th Cong., 2d Sess., 560 (1980).

5/ Congressional Research Service, Factors affecting the Export of High-Sulfur Coal from the Eastern Interior Basin, Cmte. on Governmental Affairs, United States Senate (1981).

6/ Effect of Coal Quality on Maintenance Costs at Utility Plants DOE/ET/12512-1, U.S. Dept. of Energy (1980).

7/ New York Times, D-4, June 4, 1981.

forming minerals from raw coal before combustion."8/ When used in conjunction with flue-gas desulfurization, beneficiated coal "can substantially reduce the level of continuous sulfur dioxide removal that an FGD system must contend with, and at less cost than the FGD capacity which it replaces." 9/ The Otisca Process beneficiates coal in the following manner. Raw coal from the mine is placed in a liquid bath of certain chloroflouromethanes (CFMs) the density of which is about 1.50 gms/cm^3. The bath allows the less dense coal to float, making it easily removable from the surface. The more dense gangue, or refuse material, i.e., mineral matter including sulfur compounds, is recovered separately. Importantly, the Process is conducted in a closed system, and the CFM entrained on both products after bath separation is removed by evaporation for reuse in the Process.

When used for steam generation, cleaned coal recovered from the Process can in many cases meet EPA's clean air standards for new boilers and, in the other cases, dramatically reduce the sulfur and ash load to the after-burner scrubbers. In addition, use of the Process is not confined to the cleaning of raw coal. It may also be employed to recover coal from slurry ponds, gob piles as well as oil from tar sands.

There are several other types of coal cleaning techniques currently in commercial use (e.g., hydrobeneficiation, air separation, jigging, froth flotation, cycloning and shaking on Deister tables) which do not use CFCs, but none is as efficient and economical as the Otisca Process for fine coal cleaning. Conventional hydrobeneficiation facilities, for example, are now used to clean a very large fraction of the coal mined in the United States today (600 X 10^6 tons produced per year). In comparative tests, however, Otisca-cleaned coal has not only been found to result in higher BTU yields, it also produces far less sludge, boiler refuse, noise and dust. At the same time, it extracts more pyritic sulfur as well as mineral impurities that can be accomplished through water cleaning. As a result, the more efficient extraction of mineral matter by the Otisca Process reduces the load on electric precipitators and power plant fly ash disposal facilities.

Further, because the Process is self-contained, it avoids several environmental penalties associated with conventional hydrobeneficiation. While the hallmark of these facilities is the discharge of large volumes of contaminated "black water" into settling ponds, the Otisca Process is characterized by ultra-efficient recovery and recycling techniques, allowing nothing ecologically detrimental to be discharged.

8/ Roman, Beneficiation: An Alternative to 100 Percent Flue Gas Scrubbing, Coal Mining & Processing, 68 (September, 1980).

9/ Id.

Equally important, in many cases Otisca Processed coal is cleaned at a cost well below that of hydrobeneficiated coal. In fact, if EPA were to tighten its water pollution rules relative to hydrobeneficiation facilities as has been proposed at 46 Fed. Reg. 3136 (1981), this cost differential is likely to increase in view of the capital investment required to achieve compliance. Also, hydrobeneficiation processes typically require substantially more energy than the Otisca Process to clean equivalent amounts of coal. Because of the many advantages of the Otisca Process, it has the potential of making a significant contribution to our nation's environmental program at a time when far greater demands are being placed on coal for power generation.

The Importance of CFCs to the Otisca Process

The use of CFCs as a parting liquid is critical to the Otisca Process. One of the principal reasons that Otisca can recover coal at a lower cost than existing hydrobeneficiation systems is that the parting liquids which it uses are presently available in large quantities at a relatively modest cost. Equally important is the fact that extensive research has disclosed no viable alternatives to CFCs as a parting liquid.

The CFCs used in the Otisca Process permit the sharp and rapid separation of coal and associated foreign matter. Even pyritic sulfur particles as small as 0.001 inch in diameter can be efficiently removed because of the excellent wetting properties of CFCs. Conventional hydrobeneficiation, on the other hand, become inefficient to an increasing and dramatic degree as particle sizes decrease below 0.02 inch in diameter and becomes totally inoperable at particle sizes lower than 0.005 inch in diameter. Hydrobeneficiation, therefore, unlike the Otisca Process, is inherently incapable of removing much of the pyritic sulfur which may be present in a particular seam of coal.

Moreover, because the CFCs used in the Otisca Process have an extremely low latent heat of vaporization, the parting liquid can be recovered from solids with which it has been associated by evaporation with only a modest expenditure of energy. As used in the Process, CFCs are non-corrosive, non-toxic and non-flammable, thus contributing to the longer life and safety of a particular processing plant without impairment of the health of the operators. Moreover, CFCs enable the Process to be efficient even when the moisture content of the coal to be processed is high. In fact, coal with a moisture content as great as 15 percent can be readily cleaned. There is also no tendency for slimes to form in the Otisca Process even in circumstances where signficant amounts of clay are present. This is particularly noteworthy as the control of slimes in other gravity separation processes has become a pressing problem.

Further, CFCs will not leave corrosive or other unwanted residues on the product coal, but are completely recoverable to the extent that virtually all of the liquid is recyclable. Previous use of halocarbons as a density separation method for cleaning coal commercially proved to be impractical because these liquids reacted chemically with the coal and refuse matter typically associated with mined coal, thus inhibiting complete recovery of the halocarbons. Also, organic residues resulting from the use of these other chemicals contaminated the coal. In contrast, CFCs are chemically inert with respect to coal under the process conditions employed by Otisca. From a mechanical standpoint, CFCs permit the Process to be operated at ambient pressures and temperatures. Also, there is no need to separate raw coal into large and small particle batches as is necessary in presently employed coal cleaning processes, again eliminating another substantial energy requirement.

As can be seen from the above, CFC coal cleaning technology is not only more efficient and economical than comparable systems, it uses less energy. Clearly, neither our national environmental goals nor our energy objectives would be well-served by denying companies such as Otisca access to moderately priced supplies of CFCs or by barring their use in cleaning coal.

The Impact on Otisca if EPA Fails to Resolve the CFC Issue

Otisca is regularly approached by coal producers and coal users interested in purchasing our services in order to meet clean air standards and burn coal more efficiently. Although our systems are less costly than conventional ones, their construction and maintenance still require a great deal of money. For example, the capital cost of a typical 500-ton-per-hour plant is about $15 million, $10 million of which is the direct cost of the system needed to recover the CFCs for reuse at the conclusion of the cleaning process. The operating cost of the plant would be approximately $2.00 per ton of raw coal, of which 15 to 30 percent constitutes the cost of the chemical. Because the design life of such a plant is ten to twenty years, some potential customers have been reluctant to make the capital outlays necessary to install a facility until they are confident that EPA will not move against CFCs. There is no question that this uncertainty must be resolved if Otisca is to survive.

The Impact of the Six Options on the Otisca Process

Of the six options discussed in the ANPR, EPA seems clearly to favor Options IV, V and VI, the "economic incentives" approach. Here, the ANPR states that EPA using the price mechanism would force firms "to decide whether to continue to use CFCs and pay the higher price, or switch to substitute chemicals or processes to reduce CFC consumption." 45 Fed. Reg. 66730. Option IV would establish production ceilings for CFCs, Option V would provide direct allocation of CFC permits to user industries, and Option VI would allow EPA to auction permits to manufacturers.

Each of these options, if implemented, would have a devastating impact on the Otisca Process. As is readily apparent from the foregoing, the continued viability of the Otisca Process is a function of the continued availability of CFCs in large quantities at moderate prices. Options IV, V and VI, however, would result in dramatically increased and constantly fluctuating CFC prices. Equally distressing, the continued availability of CFCs would be called into question. Because Otisca is in the business of selling coal-cleaning technology and associated services, marketing the process would be extremely difficult, as Otisca and its potential customers would no longer be able to estimate with any degree of certainty the costs of the Process and, indeed, whether it would even be available. In addition, raising the price of CFCs would eliminate the cost advantages that Otisca has been able to achieve over less efficient coal cleaning technologies.

Switching to substitutes would also be an unrealistic alternative. Other halogenated solvents have been widely tested, yet none possesses the necessary properties of inertness, non-toxicity, non-flammability, correct density, viscosity and ease of vaporization.

Turning to the specific options, Option IV would place production ceilings on CFCs to induce manufacturers to raise their price. 45 Fed. Reg. 66731. Thus, EPA will "consider methods which minimize the windfall to manufacturers and minimize impacts on users." Id. In other words, this alternative contemplates artificially increasing the price of CFC's to discourage their use but recognizes users may suffer. Implicit in the alternative is some theory of compensating users from manufacturers' "windfall" profits. The impracticalities of such a theory, including both its complexities and cost of administration, are self-evident. Moreover, no consideration is given to the loss of jobs, capital investment, and profits which would have been produced had CFC's been produced and sold normally.

Option V would allow EPA to make direct allocation of CFC permits to user industries, acknowledging that "an equitable allocation would [be] extremely difficult to implement." 45 Fed. Reg. 66731. If this method is chosen, it is not clear from the ANPR how industries such as Otisca would be treated. The Otisca Process has only recently reached the commercialization stage and the signing of additional contracts for its coal cleaning services is anticipated. Consequently, Option V would make the very existence of a company such as Otisca vulnerable to arbitrary allocations of CFC permits by EPA based on standards which remain unidentified either generally or specifically.

Option VI would also increase the cost of CFC's as a means of holding down its production. This, as would be the case with Option IV, is likely to reduce the cost advantage of the Otisca Process to such an extent as to make it impractical. It also ignores the impact of excessive costs on users, which the ANPR recognized as a concern under Option IV.

The "mandatory controls" approach, while less onerous than the economic incentives, could still adversely affect the Otisca Process. Option I would establish some type of "mandatory control technology" standards, Option II would selectively place outright bans on certain products or users of CFCs, and Option III would limit individual use of CFCs. In view of the Otisca Process' ultra-efficient recovery and recycling techniques, Option I would at least give Otisca a chance to survive while EPA attempted to prove or disprove the ozone depletion theory. If Option II were to be chosen, it would be essential that EPA recognize the Otisca Process as a technology to which mandatory controls could be applied. This option also seems to embrace an approach missing in the "economic incentives:" let industries continue to use CFCs as long as emissions are reduced or eliminated. If EPA is intent on raising the cost of using CFCs, why not let users spend additional funds on their recovery systems in order that important applications such as the Otisca Process are not lost instead of siphoning these funds away to increase manufacturers' profits or the government's revenues.

With respect to Option III, obviously that approach would only be acceptable to Otisca if EPA were to recognize the health and environmental benefits provided to the American public through use of CFCs in coal cleaning. Reliance on Option III, however, would not be desirable partly for the reasons advanced by the ANPR at 45 Fed. Reg. 66730. The administrative delays inherent in a certification process would lessen the attractiveness of the Otisca Process to purchasers of coal cleaning technologies. Finally, Option III could sharply curtail further application of the Process.

A Comment on the Depletion Theory Itself

The ANPR states at several points that EPA has yet to find conclusive evidence that CFCs have a destructive effect on stratospheric ozone. EPA would not question, however, the assertion that sulfur and fly ash emitted by coal burning facilities constitute harmful atmospheric pollutants. Nor would it question the environmental problems inherent in slurry ponds and contaminated water resulting from hydrobeneficiation processes. Thus, on the basis of questionable ozone depletion theories, EPA would wipe out a process that unquestionably results in a cleaner environment.

Otisca has closely followed the Ozone/CFC issue since announcement of the Rowland-Molina hypothesis, constantly seeking hard, quantifiable data either supporting or denying the theory. It is presently our opinion that after nearly seven years of scientific investigation, the scientific institutions, rather than removing uncertainty, have added numerous new questions that require clarification in order to establish even the validity of the theory. Of particular relevance is the inability of the National Academy of Science (NAS), the United Kingdom's Stratospheric Research Advisory Council (STRAC), and the committee advising the European Economic Community, while using the same data base, to reach a consensus on the alleged or even extrapolated danger of CFC release. In fact, both STRAC and EEC counsel the need for further research and stress the importance of not overreacting to ill-defined consequences of an as yet unproven theory.

Attached as appendices are two articles illustrating the uncertainties surrounding the depletion theory. A study by Murad, Swider and Benson demonstrates that the NAS study failed to take into account the total flux of matter coming into the stratosphere in the form of meteor metals when computing impact of CFCs on the stratosphere. That flux, which is equivalent to the total mass of all CFCs produced on the earth's surface, may act as a scavenger for halogens, thus protecting the ozone layer. Benson goes on to say that if there really is some problem threatening the ozone layer, the release of sodium compounds into the atmosphere could eliminate excess chlorine.

Under these circumstances Otisca finds it very difficult to understand how EPA can so definitively reject what it characterizes as a "wait and see" approach on the basis of information, already obsolete, supplied by NAS's Committee on Impacts of Stratospheric Change (CISC).10/ Instead of first determining whether or not the depletion theory is correct by adopting a policy of aggressive scientific investigation, EPA has decided to take regulatory action which would result in the immediate elimination of industries such as Otisca whose technologies have clearly demonstrated a provable impact on known pollutants.

Moreover, the CISC report states that an "early warning system" capable of monitoring "whether ozone depletion due to human activity is indeed occurring. . .could provide the basis for implementing regulation against that activity." 11/ CISC goes on to conclude and the ANPR paraphrases, "validation of the

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10/ The original model predictions for ultimate ozone reduction and its rate of occurrence has been drastically reduced by experimentally verified reactions rates which EPA concedes are valid. See testimony of EPA on July 15, 1981, before the Subcommittee on Antitrust and Restraint of Trade Activities Affecting Small Business, House Committee on Small Business. Using the model relied on by EPA to justify the ANPR, the figures on steady state depletion (100 years), for example, have been revised from 18.0 percent to 7.0 percent with 1.5 percent predicted depletion by the year 2000.

11/ NAS, Protection Against Depletion of Stratospheric Ozone Depletion by Chlorofluorocarbons 54 (1979).

ozone depletion theory through environmental monitoring is limited because a minimum ozone change of approximately five percent over a period of 10 years would be required before a depletion could be observed with statistical confidence." 12/ This in fact is not the case, and statistical methods now exist to detect changes of ± 1.25 percent per decade in total global ozone as well as meet the requirements defined by CISC for an adequate "early warning system." A panelist who sat on both the 1976 and 1979 NAS committees has conceded that these statistical methods are as sensitive as industry has been claiming, and that he and other panelists had been unaware of that fact at the time the NAS report had been prepared for Congress. 13/

Conclusion

The Otisca Process which cleans cloal of its pyritic sulfur and mineral (ash) impurities offers the following promises:

(a) High sulfur Eastern coal can be cleaned to levels more competitive with lower sulfur coals.

(b) Jobs threatened by the unsuitability of "dirty" coal reserves could be saved.

(c) The inflationary pressures of abatement devices such as precipitators, scrubbers, required to meet clean air standards, would be reduced.

(d) The environmental penalties associated with less efficient, conventional hydrobeneficiation techniques (i.e., energy, noise, dust, black water, boiler refuse, greater sulfur and ash levels and lower BTU yield) would be lessened.

Otisca, therefore, urges that Congress adopt S. 517 as an amendment to the Clean Air Act.

Very truly yours,

OTISCA INDUSTRIES, LTD.

Clay D. Smith

Clay D. Smith
President

12/ 45 Fed. Reg. 66729.

13/ Comments of Geoffrey S. Watson on the ANPR by EPA at 45 Fed. Reg. 66726 (1980).

A Statement

By

Whirlpool Corporation

Whirlpool Corporation respectfully submits comments regarding the Environmental Protection Agency's (EPA) efforts to further regulate the use and production of chlorofluorocarbons (CFCs). Whirlpool is a leading manufacturer and marketer of major household appliances. A large portion of our total product lines consists of refrigerators, refrigerator-freezers, freezers, central and room air conditioners, commercial and home ice makers, and dehumidifiers. The use of CFCs is integral to our production operations, both as a refrigerant in our products' cooling systems and as a blowing agent for insulating foam used in refrigerators and freezers. Although Whirlpool's total usage of CFCs represent somewhat less than one percent of total U.S. production, EPA's proposed regulation to limit the production and availability of all forms of CFCs will have a tremendous and devastating impact on our business.

As such, we support Senator Bentsen's bill (S. 517) which would preclude further EPA regulation of CFCs until additional studies can substantiate the ozone depletion theory. Our reasons for supporting this legislation are as follows:

Ozone Depletion Theory

The ozone depletion theory, authored by the National Academy of Science (NAS), and which now serves as the springboard for the EPA's proposed regulation of CFCs, is not universally accepted by the world scientific community. Equally knowledgeable scientists in Great Britain's Department of the Environment's Stratospheric Research Advisory Committee, along with several prominent American scientists, suggest that there are numerous questionable assumptions in the NAS study. The UK team concluded that the validity of NAS's theory is still in doubt. Several scientists have gone so far as to suggest that the foundation of the NAS study is based more upon speculation than it is upon a more disciplined body of scientific knowledge.

We believe that publication of regulations, the basis of which rests purely upon hypothesis or theory, establishes a dangerous precedent that could lead to an avalanche of additional regulations that are equally unsupportable by empirical evidence.

It would appear to us that the economic impact of the proposed regulation upon manufacturers and upon consumers is far too great to proceed purely upon the basis of theory. A study commissioned by the European Economic Community reported that a delay of five years before any decision is taken on CFCs can be reasonably accepted. Given the disagreement within the scientific community on this issue, it would seem reasonable to adopt Senator Bentsen's bill which would require further study and validation of the ozone depletion theory prior to proceeding with further rulemaking.

International Participation

Although the "CFC problem" is global in scope, EPA proposes to unilaterally restrict the availability of CFCs in the United States, in the hope that other nations will emulate America's lead. The severe reservations European scientists have with the NAS theory strongly suggest that international restrictions of CFCs will not be attainable. Past experiences also suggests other nations will not follow U.S. EPA's lead. EPA has published that only Sweden, Norway and Canada banned the use of CFCs as aerosol spray propellants when U.S. EPA promulgated an earlier regulation to restrict CFC use.[1] Indications today are that neither the European Economic Community, nor Japan, intend to apply restrictions under EPA's present proposed rule, in which case U.S. manufactured products would be at still one more severe competitive disadvantage in international markets.

In 1979, imports of all CFC-based home appliances into U.S. markets numbered approximately 629,000 units. In the case of refrigerators, 1979 imports represented a very substantial 8.6% of total U.S. share of market. The U.S. would have to regulate foreign imports to the same degree as it would American products in order to protect American appliance manufacturers. However, if such action were taken (but, due to the global nature of the "ozone problem," we feel enforcement would be impractical), such a trade barrier could spark retaliatory measures in kind -- especially from nations who legitimately disagree with the ozone depletion theory.

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[1] "CFC's, Ozone, and Health," Toxic Information Series, OPA Document 124/0, U.S. Environmental Protection Agency, Office of Toxic Substances, Industry Assistance Office (TS-793), undated, p.3.

Energy Considerations and Lack of Alternatives

Since 1972 the appliance industry has achieved energy efficiency gains of 45.2% (refrigerators), 47.6% (freezers), and 17.2% (room air conditioners). Whirlpool has exceeded industry averages with efficiency gains during the same period of 89% (refrigerators), 96% (vertical freezers), 49% (horizontal freezers), and 18% (room air conditioners). In part, a measure of our success is attributable to the availability and proper use of CFCs in these products. An explanation follows:

*Use of CFC-11

One of the most effective ways to increase efficiency in refrigerators and freezers is to use foam insulation between the liner and the cabinet. There has been a steadily increasing application (60% within Whirlpool) of foam in the domestic refrigerator business over the past several years, as consumers have opted for more efficient products. Polyurethane foam, which uses CFC-11 as its blowing agent, has superior thermal conductivity properties which are roughly twice as effective as fiberglass. Known alternatives to foam like fiberglass (as an insulation) or carbon dioxide (as a blowing agent) are poor alternatives. In fact, there are no known alternatives to CFC-11 which are as safe, non-toxic and effective in achieving superior insulation. Consequently, efforts to regulate CFC-11 will prove detrimental to our continuing thrust to develop increasingly energy efficient appliances.

*Use of CFC-12

CFC-12 is the refrigerant of choice in refrigeration systems designed to preserve food in home refrigerators and freezers. These systems operate at 110°F condenser and -15°F evaporator. The most logical alternative to CFC-12 is CFC-22. However, because of thermodynamic property differences, its use creates approximately a 2.3% energy penalty in efficiency loss. A second alternative, R-502 (a combination of CFC-12 and CFC-22) has an even greater energy penalty of 4.4%.

In addition to CFC-12's superior refrigerant qualities, it is also safe for consumer use. In fact, the use of CFC-12 has evolved because of the characteristics of its predecessors, ammonia and sulfer dioxide.

Besides the higher cost and restricted availability of alternatives to CFC-12 (competition for CFC-22 will be heightened if 11 and 12 are less available), reliability will become a major concern. Higher discharge temperatures of CFC-22 could create increased compressor failures.

Finally, redesigning refrigerators and freezers to use CFC-22 would require extensive system changes and corresponding product development. Not only would compressor changes be required, but heat exchangers and restrictors would also need to be redesigned in order to accommodate the use of CFC-22.

Similar comments also apply to dehumidifiers. However, since dehumidifiers operate within a narrower band of temperatures (45°F evaporator and 120°F condenser), the number of changes needed would be fewer. The energy penalty in using CFC-22 would be 3%, and the product changes would be slightly less. However, these changes would still represent a significant cost increase to consumers.

*Use of CFC-22

Air conditioners use CFC-22 because it is the most appropriate for optimum operating conditions. Under the proposed EPA regulations it would be the most available refrigerant. However, it is likely that a cap on production and subsequent switching to CFC-22 by other users would force its price upward.

Product Pricing and Availability

Restricting the availability of CFCs will necessarily constrict the number of refrigerators, freezers, room air conditioners and dehumidifiers available for sale. In a free market economy, we can expect this limitation not only to drive up consumer prices, but also to create a scarcity of CFC-based appliances. Appliance manufacturers have been highly successful in moderating consumer price increases at about half the overall 1980 increase in the CPI, and at the same time offering an increasing number of product convenience features. To limit CFCs would create a severe obstacle to continuing this trend.

Summary

A Rand Corporation Study commissioned by EPA states that CFC-based home appliances are a "poor target for regulatory action."[2] The study found that the level of CFC emissions from all home appliances was less than some of the "miscellaneous" products included in its analysis. "By 1990," the study reports, "even in the absence of policy action, home appliances will emit less than 10 million pounds of fully halogenated CFCs." (This compared to a 1990 total U.S. consumption rate of 794 million pounds.[3]) Additionally, a Department of Energy (DOE) analysis clearly supports a position that appliances should receive low priority for regulation when it concludes that CFC emissions from all household appliances are only about two percent of total U.S. emissions.[4] The effect of regulating CFCs used in home appliances would have only a miniscule impact on reducing the two percent usage factor, thus casting further doubt on any cost/benefit considerations.

The appliance industry represents a relatively small segment of total CFC-users. In all applications, CFCs are contained either through hermetic refrigeration or foam systems which prevent the release of CFCs into the atmosphere until after the life of the product is spent. Implementation of EPA proposals to impose additional restrictions on the use or production of CFCs could have far reaching economic and energy consequences which transcend the unproven environmental considerations.

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[2] Economic Implications of Regulating Chlorofluorocarbon Emissions From Nonaerosol Applications, Rand Corporation, June, 1980, p. 174.

[3] Environmental Analysis (Technical Support Document No. 5), U.S. Department of Energy, Energy Efficiency Standards for Consumer Products, P. 3-24 (Tables 3-6).

[4] Ibid, p. E-2. (In making this statement, DOE cites as its source the National Academy of Science study, Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons, Washington, D.C., 1979.)

In short, Senator Bentsen's alternative (S. 517) represents a common sense approach which would allow the EPA to assess with greater assurance the impact and validity of the ozone depletion theory prior to imposing further regulatory burdens on an already suffering economy.

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